AN ABSTRACT OF THE THESIS OF

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Although a concern for gender equity provided the framework for this research, the results of this study highlighted the fact that the question of equity should be broadened to include concern for the tier of talented women *and men* who currently choose not to persist in an undergraduate computer science major. This investigation captured the experience of three male and two female first year undergraduate computer science majors (and two instructors) over the course of their first two college terms. Sources of data included interviews, classroom observations, electronic mail journal comments, and casual conversation.

Subtle elements of potential gender discrimination were a part of the rich data collected but the students did not mention such factors. Rather, in faithfully portraying the students' perspectives, this research presented the students' candid discussion of the function of more obvious factors in their experiences.

Difficulties with concepts of mathematical proof and computer programming were significant factors in the students' experiences. Students not experienced with mathematical proof or computer programming failed to develop an understanding of the basic principles in the respective course. Student difficulties were matched by the struggles of teaching faculty as they looked for input to support improvement in their teaching.

Many of the factors identified by the students were found in the general undergraduate experience. All of the students knew little about careers in computer

science and were anxious to learn more. The female students wanted their career to involve work they enjoyed. The male students wanted assurances that they could compete and find financial security in their career. The students valued support they found in a variety of forms and were disappointed in the lack of support found in advising sessions. Students struggled with inadequate study skills to meet demanding course expectations.

This research identified factors in the culture of undergraduate computer science education that impacted students' decisions to persist, or not persist, in the field. The results indicate changes and provide a basis for the design of interventions aimed at creating an environment that will equitably support *all* persons in pursuit of an undergraduate computer science degree.

The Culture of Undergraduate Computer Science Education: Its Role in Promoting Equity Within the Discipline

by

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I understand that my thesis will become part of the permanent collecton of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Kathy Howell, Author

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Clearly, I owe my appreciation to five students and two instructors who were willing to share themselves with me and this study. They trusted that the sharing of their experiences would enlighten improvements in the system of computer science education. Their open honesty is one of the strengths of this study.

But now the study is done, the dissertation is complete, and life is good. Actually, life has been good throughout this process! A loving God fills my life with abundant blessings; most obviously I share life with gracious and loving friends. From the FAMI neighborhood to my Mennonite Fellowship to kids overflowing with hugs and smiles, I always knew that I was loved no matter what I was doing (or not doing).

God has many faces and they've all allowed me to live life rather than be absorbed by a graduate student's life. Mom and Dad offered few opinions beyond their belief that I could accomplish anything I set out to do. Gwen knew when to stand behind me and push, when to stand beside me and hold my hand, and when to get in front of me and set my priorities straight. Maggie knew me well enough to know not to push and always let there be "Dining with Dave." Innumerable others have fed me as well. Sometimes it was food, sometimes it was talk, love in many forms, they didn't let me miss out on life.

So, while it seems a major accomplishment to be finished with this thing, it is Pooh who speaks the real truth. "When you are a bear of very little brain, and you think of things, you find sometimes that a thing which seemed very thingish inside you is quite different when it gets out into the open and has other people looking at it." My friends keep reminding me that loving is the big thing. I'm ready to take the energies invested here and get on with life, loving.

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THE PROBLEM

Introduction

The numbers describe a problem that is already far too obvious. In 1990, 7.8% of computer science professors were female and women earned only 13% of doctoral (PhD) degrees in computer science. The evidence continues to accumulate demonstrating that many women who initially choose computing either drop out of the academic pipeline, leave academia for industry, or in any case, terminate their training earlier than men (Widnall, 1988).

In light of current United States demographics, the participation of women and other underrepresented groups must increase to meet the future demands for trained scientists and engineers (Pearl et al., 1990; Spertus, 1991; Widnall, 1988). Likewise, development within the computer science discipline is handicapped by the loss of potential creativity, talent, and perspectives that could be contributed by women and other underrepresented groups.

Research that has investigated the experience of women in computer science has looked at various aspects of computer science education and student involvement with computers. As the terms are used here, *computing* refers to the general use of computers and computer applications. A *computer science course* is any course that a student completes as part of the computer science coursework required for a computer science major. *Computer science education* is used as an umbrella term meant to include all those experiences of students enrolled in computer science courses as they spend time in classes and the computer laboratory, complete assignments, and relate to other students, faculty, and staff. *Successful students* or *persisters* are students who declare a computer science major and then fulfill the necessary requirements to complete a computer science major. *Unsuccessful students* or *non-persisters* are students who declare a computer science major and do not complete the major for

some reason. *Culture*, as defined by Eisenhart (1990), is used to represent "those collective interpretations of social and material experience that are more or less shared by members of a group and available to be acquired by individuals who interact in the group" (p. 22).

It is to be expected that many college freshmen change their choice of major as they face the realities of coursework and make the adjustment to college (Jacobs, 1986; Tinto, 1988). Campbell and McCabe's (1984) research with freshmen computer science majors, however, found a 49% persistence rate within the major for males and only 27% for females. Do the rites of passage in computer science education and the criteria implicit in the freshman "weeding out" process turn away many good students from a computer science major and perpetuate disproportionate female-male participation in the discipline? Research since the Campbell and McCabe research has attempted to identify factors that contribute to the situation but the research has focused largely on factors that cannot be affected once women become undergraduate students.

Comfort and feelings of self-efficacy were found to be important factors in women's decisions to enroll in computer science courses (Bernstein, 1991; Lips and Temple, 1990; Miura, 1987). Kersteen, Linn, Clancy, and Hardyck (1988) found that men were much more likely than women to have self-initiated prior experience with computers. Without this prior experience, freshmen women were more likely to describe the content of computer science courses as confusing (Sproull, Zubrow & Kiesler, 1986). This lack of experience was manifested in women's lower confidence than men in personal abilities (Lips & Temple, 1990; Miura, 1987; Teague & Clarke, 1991; Ware, Steckler & Leserman, 1985). Lack of confidence then became a significant factor in the decision of many women as to whether to persist with a computer science major (Lips & Temple, 1990; Ware, Steckler & Leserman, 1985).

Perceptions of computer scientists and a computer science career were also found to play a role in the decision to major in computer science (Teague & Clarke, 1991). The image of the hacker and the hacker's intimate relationship with the computer was a factor that discouraged women from becoming involved with computing (Turkle, 1988).

The research considering influential factors that develop more directly out of the culture and environment surrounding computer science education offers more

direction for improvements in a system that currently discourages some students (many of them women) from computer science courses. As the minority in a culture dominated by males, women brought different concerns, priorities, and goals to the study of computing than those typically rewarded by professors and held by the male majority (Rasmussen & Håpnes, 1991). The typical environment of computer science education was described as competitive and individualistic. Many women found it difficult to succeed in this type of environment, an environment preferred more by men than women (Harrington, 1990/1991; Sproull, Kiesler, & Zubrow, 1987).

In this environment professors and teachers generally characterized a good computer science student as one who was a risk-taker, absorbed in work (Rasmussen & Håpnes, 1991). Women found this hacker's style of learning to be difficult and found structured programming (the programming style espoused as the right way of proceeding) to be uncomfortable and in conflict with a naturally artistic and communicative style (Turkle, 1988).

The study of computer science involves the student in a distinctive set of contexts, contents, and values. Turkle (1984) delineated two contrasting approaches to human communication and relationships. One approach emphasizes the importance of conversational communication and values the ambiguity of human relationships — relationships are approached in a negotiating style. In contrast, the perspective and approach rewarded by the vast majority of experiences in computer science education values abstraction, imposition of will, clarity, and risk taking. Turkle (1988) contended that the culture surrounding computing alienates many persons for whom communication, even with a computer, is approached in a different style.

Statement of the Problem

Much of the research concerned with women and computing has either focused on the pre-college experience or on general attitudes toward computing. The limited body of research dealing with the gender problem at the undergraduate level, however, has many weaknesses and provides few answers. Many studies have made use of questionnaires for data collection (e.g., Bernstein, 1991; Clarke & Chambers, 1989; Lips & Temple, 1990; Miura, 1987; Sproull, Zubrow & Kiesler, 1986). As the research attempted to assess complex social constructs, lack of established reliability

and validity limits interpretation of the results. Assessing how students experience different factors in the culture of computer science education is difficult with a traditional questionnaire approach that provides only a single snapshot in time of students' experiences. Questions can be interpreted differently by each individual. Answers may reflect the subject's "questionnaire answer" rather than the answer displayed in the actual situation.

Qualitative research examining the culture of computer science education has produced more promising results, however, few studies of this type have been reported and many of these studies suffer from common limitations. Some of the studies (Harrington, 1990/1991; Turkle, 1988) utilized an all female sample of successful students. Results derived from an all female sample fail to distinguish whether factors are unique barriers to women or barriers unique to computer science education for all students. A sample that excludes unsuccessful students fails to identify obstacles that successful students have conquered and no longer consider to be obstacles. Only one study (Rasmussen & Håpnes, 1991) included a mixed sample of males and females and also included faculty and staff perspectives of the culture. Teachers and professors have a major impact on the experience of students and any description of computer science education is incomplete when this viewpoint is omitted.

A weakness in the entire body of research dealing with the experience of women in undergraduate computer science education is that none of the research has been of a longitudinal nature. The research has found that many students make the decision to not persist early in their freshman year (Cope & Hannah, 1975; Tinto, 1988) but one time questionnaires or interviews fail to capture the richness of the experience or describe the development of coping strategies and attitudes.

The experience of students in their first computer science courses establishes student perceptions of work required to complete a computer science major. Sproull, Kiesler, and Zubrow (1987) described the reaction of freshmen computer science students to their first computing course as one of reality shock. The students felt that the study of computer science was much different from courses with which they were familiar and it made them feel out of control. Campbell and McCabe (1984) found that only 40% of incoming freshmen computer science majors had *not* changed their major after one year. The research of Ware, Steckler, and Leserman (1985) revealed that a few months into the freshman year 20% of students initially interested in a

science major had changed their mind. By the end of the freshman year 50% of the women and 31% of the men were no longer declaring a major in a scientific field. Certainly many potentially excellent computer science majors based a change in their major on their early experience in college and university computer science courses.

What aspects in the academic environment surrounding computer science education support students, particularly women, in their decision to study computer science? What are the factors that deter good students (women and men) from persisting in a computer science major? Classification models based on Scholastic Aptitude Test (SAT) scores and high school experience may be interesting but contribute little toward changes in undergraduate computer science education supporting underrepresented groups of students' entry into the discipline.

This study identifies factors in the culture of computer science education and describes how these factors operate together in the experience of freshman undergraduate students to encourage students to persist or not persist. Many of the factors identified are factors that can be affected to improve the situation and support the development of the discipline of computer science through the contributions of persons currently alienated by the traditional freshman experience in computer science education.

Significance of the Study

The percentage of women in the total enrollment of higher education is increasing (Kick & Wells, 1993). Why, at the time of a female enrollment increase, is the enrollment of women in college and university computer science programs declining? What factors in computer science education operate to yield higher rates of non-persistence for students who are members of underrepresented groups within the discipline? Realistic factors influencing the experience of undergraduate students in computer science can be identified by careful observation of the culture surrounding computer science education. Little research of this type has been reported and additional research is necessary to paint a more complete picture of the culture that has developed. The encouraging outcome of this type of research is that many of these cultural factors can be changed to improve the experience of all students in computer science education.

The argument has been made (Alper, 1993) that the dropout rate for women will continue to be high until scientists reevaluate and change their basic conception of a scientist's behavioral characteristics. As Frenkel (1990) pointed out, the field of computer science is young and flexible enough to modify itself. Researchers are beginning to look for gender free paradigms for computer science education (Martin, 1992) and recognize the importance of the many ways of knowing and thinking within the discipline (Turkle & Papert, 1990). The results of this research serve as a basis for further research focused on specific factors identified. The research results indicate changes and provide a basis for the design of interventions to determine whether an environment for computer science education can be created to equitably support *all* persons in pursuit of an undergraduate computer science degree.

CHAPTER II
REVIEW OF THE LITERATURE

Introduction

This study describes the experience of freshman undergraduate computer science majors as they began their coursework in computer science. The research results identify factors that influence students to persist or not persist with a computer science major. The previously available research that addresses the gender differences in persistence in undergraduate computer science can be classified into two categories: (a) studies that have contributed to an understanding of the culture of undergraduate computer science, and (b) studies that have attempted to isolate and assess the influence of specific factors that may influence computer science students' decisions to pursist in the discipline. The distinguishing feature of these categorizations is whether the research considered factors to operate in an interrelated manner in a complicated social situation (culture) or whether the research identified individual factors of interest *a priori.*

The Culture of Undergraduate Computer Science Education

Rasmussen and Håpnes (1991) presented a case study of the computer science culture at the Norwegian Institute of Technology (NIT) as part of a research project dealing with the different types of computer studies at the university level in Norway. Rasmussen and Håpnes chose the research direction based on the argument that "the *culture* of computer science is important in producing and reproducing male domination in higher education in computer science" (p. 1108). This case study was thorough but findings must be evaluated in light of the fact that little information about the researchers, interview techniques, or background of the subjects was reported.

NIT was the most male-dominated of the Norwegian cases. Female students comprised only between 8% and 10% of the student population. The case was presented from the perspective of five different groups: the female students, the

hackers, the dedicated students, the professors and teachers, and the rest of the male students (referred to by the authors as the *normal* male students). Other than the group of female students, the groups were all male.

The dedicated students saw the hackers as rivals and had no relationship with them. The dedicated students worked long hours in close cooperation with the professors and their projects. They conformed to the culture of the subject and were dependable and hard working.

The hackers defined themselves as an alternative culture within the computer science department. Within the group of hackers, the hackers shared common cultural traits (lifestyle, nocturnal working hours, language), but individual hackers worked to distinguish themselves as individuals within the group by dress, hair, or being the only "normal" hacker. The hackers were not loners. Their social lives were shared with other hackers and were occupied with their main interests including science fiction and computers.

The hackers had no contact or knowledge of the female students nor the normal male students. The hackers had never really considered why female hackers did not exist. They were at a loss to explain why no women were interested in computers in the same way as the hackers were. They were aware of the dedicated students but had little contact with them. Only out of need did they make some contact with professors and teachers. The hackers saw a fairly strong relationship between the dedicated students and the professors and teachers.

The female students were nontraditional compared to the majority of women. They struggled with the idea of studying computer science and becoming a part of a group of students with an image as "freaks." They were relieved to find other students within the department who left the computers at the end of the day, had a social life and, in general, enjoyed activities other than computing.

The female students best characterized themselves by what they were not, "key-pressers." The female students categorized both the dedicated students and the hackers as key-pressers. The female students saw the key-pressers in an intimate relationship with the computer, spending as much time as possible sitting in front of the computer programming. The female students were threatened by this idea of cultural and social isolation.

The female students were attracted to the field of computer science because of interest in how you make objects work and how you can use computers and computer systems. In contrast with the males, however, the females had different professional interests and concerns. Rasmussen and Håpnes (1991) made the point strongly that the women were interested in applications and the user side of computing — the "soft" side of general computing. The women saw the men as concerned with technical, mechanical aspects of computing whereas the women were more interested in applying computer technology to the solution of practical problems.

The female students had no relationship with the dedicated students or the hackers. They felt that their relationship with the professors and teachers was weak at best while they did recognize a relationship with the normal male students.

The majority of the students fell into the normal male student category. These students had other non-computer interests and, like the female students, did not stay to work on the computers in the evenings. Support from this group may have helped to strengthen the female students' effort for recognition of the importance of computing applications and user issues in the course of computer science education. But, the normal male students were passive and did not protest.

The final group, the professors and teachers, thought that good students should invest at least 60 hours in work each week. They saw the dedicated students as better students than the hackers. They liked the risk taking and total absorption attitude of some of the male students and felt that with this attitude the female students would be better students. They saw the female students as good students but not as creative, brilliant, or likely to come up with interesting innovations.

The professors and teachers saw a close two-way relationship between themselves and the dedicated students. The professors and teachers also felt that they knew the hackers well. They saw the normal male students and female students as somewhat anonymous in comparison to the other two groups.

The authors noted that the female students saw little difference between the three "in-groups" — the hackers, the dedicated students, and the professors and teachers. This in-group perspective was so powerful that the female students could not distinguish the contradictions and opposing ideas represented by the three very different groups.

Rasmussen and Håpnes (1991) reported a comprehensive case study which presented at least three challenging ideas. First, the male-dominated culture which surrounds computer science in general was also evidenced in academia. This culture had a profound effect on the perspectives of women who studied computer science. Secondly, women brought different concerns, priorities, and goals to the study of computer science. Finally, do professors and teachers need to reconsider their definition of a "good" computer science student? Does such a student have to be a risk taker absorbed in work?

Sproull, Kiesler, and Zubrow (1987), like Rasmussen and Håpnes (1991), were interested in the effect of the computer science culture on the experiences of undergraduate students. Sproull, Kiesler, and Zubrow described research conducted in 1982 that investigated liberal arts students' socialization process within the culture of computer science education. The researchers characterized the college culture of computer science as adolescent. Though not encouraged, games, pranks, stealing time, copying software, and breaking codes were tolerated to some extent. The environment was competitive and individualistic. Moreover, the difficulties novices found in dealing with these factors were compounded as novices worked alongside others who operated comfortably within the environment.

Sproull, Kiesler, and Zubrow's (1987) description of the culture in 1982 was applicable to the culture in existence 14 years later. Students in college computer science courses were faced with demands which were unfamiliar from experience with other course work. Unlike other courses, homework needed to be done in a terminal room when a terminal was available. The tools used for studying, the computer and software, may not have been reliable and gave the student limited control. The speed and nature of computing feedback was also different from other courses. A program either worked or it did not. In other courses the student decided when the composition met personal standards or when enough problems had been worked to feel mastery of the concept. Learning in the unfamiliar conditions of computer science was further complicated by a maze of arbitrary computer conventions including exacting syntax rules and system idiosyncracies.

Sproull, Kiesler, and Zubrow (1987) suggested that these cultural demands put the novice in the role of not only learning computer science but also learning how to learn computer science. Each student brought prior knowledge and experience to the

process of assimilating new information and constructing a meaningful framework for the information. The authors proposed a model for the processes of encountering and becoming socialized into this new culture.

The model proposed that the prior experiences of individuals did not prepare them for the new culture. The initial process, then, was one of reality shock as the culture presents changes, contrasts, and surprises. This reality shock is followed by confusion about self and the environment as the individual is initially overwhelmed. If the socialization process was to be successful, the individual's attempts to control the situation must succeed. These control attempts may be explanations of behavior, extra effort or just talking with other people. In any case, these control attempts allowed the individual to explain away confusion and become comfortable with the situation. If control attempts were not successful, the person was likely to become angry or withdrawn and become a cultural dropout.

As a test for their model, Sproull, Kiesler, and Zubrow (1987) administered a questionnaire to 268 liberal arts freshmen at Carnegie-Mellon University. The questionnaire was administered during a required social science class and the sample represented 95% of the liberal arts freshmen. Students were asked to respond on a three-point scale (false, not at all true; neither true nor false; true or very true of this course) to items designed to assess reality shock, confusion, control attempts, and the socialization outcomes, academic success, anger, and withdrawal. Students were to respond for their English, social science, mathematics, and computer programming courses. Those students who did not respond in all four categories were dropped from the sample, resulting in a sample of 208 students.

Computer science students seemed to experience more reality shock and confusion in response to their courses. For items related to reality shock 79% of the students in computer science courses responded affirmatively. Averages for the other three courses ranged from 20% to 27%. The average percentage of true responses for items designed to measure confusion was 45% for computer science courses while for the other courses it was 20%.

Items related to control attempts were divided into three categories: talking to people, constructive attribution, and unconstructive attribution. Computer science yielded responses on all of the **talking to people** items nearly 20 percentage points higher than for any of the other courses. Responses for the six items of **constructive**

attribution were generally lower for computer science than other courses. The three items related to **unconstructive attribution** found that computer science students tended to externalize successes and to internalize failures.

The two negative outcomes, anger and withdrawal, were much higher for computer science than for the other courses. The anger items all found higher percentages of computer science students answering true (average of 70%) than for other courses (average of 26%). The withdrawal item was true for 41% of the computer science students and an average of 14% of the students in other courses.

The authors reported analysis of the influence of previous computing experience and gender on questionnaire responses. The only difference attributable to prior experience was that fewer students with prior experience in computing experienced reality shock.

Male students were more likely than female students to experience reality shock. Female students more often cited computer science as confusing while more male students were confused by other courses. As predicted by the proposed model, female students were more likely to talk to others (control attempt) about the computer programming course and male students were more likely to talk to others about other courses.

Twenty-three students (12 male, 11 female) were randomly selected from the liberal arts freshman class to discuss their experiences with computing. The interviews were conducted by one of three trained interviewers and consisted of 29 open-ended questions. The interviews were tape recorded and lasted about half an hour. Upon completion of the interviews, the tapes were transcribed for analysis.

Nearly all the students who had taken a computer science course commented that the time demands were exceptional and that they had to schedule the rest of their life around available computer time. Most students also commented that the terminal room itself was unpleasant, crowded, and lacked privacy. Students described their first experience of actually using a computer as one where they sat down and started to punch buttons without really knowing what they were doing. They were not sure what would happen and were worried what people working around them might think.

Students also commented on their classroom experience. The majority of the students felt negatively about lectures. Apparently the students' feelings arose out of a

desire for specific help in completing programming assignments while professors attempted to present general principles.

The students' experiences with computing elicited some common reactions. Students felt a lack of control. They felt they did not know what they were doing while others around them seemed to be experts. Virtually all the students, however, reported experiencing real excitement when a program finally worked. Even students who had not taken a computing course reported pride in the work they produced using the computer. The researchers reported that especially for those students who had taken a computing course, negative reactions outweighed positive reactions.

Student perceptions of the computing culture were dominated by we/they distinctions — the "we" who did not know what we were doing and the "they" that did know and were in control. "They" were viewed as smart and competent while possessing some strange personal habits and finding "normal" conversation difficult. As another sign of cultural learning, the students demonstrated that they had learned how to correctly use some computer terminology.

Students shared some of their anger which resulted from experiences with computing. They described a struggle, a fight to get time and a fight with the system. After encountering the system, students experiencing withdrawal made comments about wanting to avoid computers and being afraid of computers.

Sproull, Kiesler, and Zubrow's (1987) research suffered from many of the same weaknesses as other questionnaire research, though the support of interview data helped to address some of these concerns. The questionnaire was apparently designed specifically for this research and no reported attempt was made to establish reliability or validity. Meanings of questions can be interpreted and responded to differently by every individual (female and male). The presented findings attempted to describe ill-defined social constructs but were based on one collection of self-report data.

With consideration for these methodological weaknesses, the findings from the interview data support the idea that culture plays a major role in shaping the novice's experience with computing. Students felt anger, frustration, and a lack of control as they completed their computer science coursework. The professor's classroom conduct, expectations, and structure of assignments and assessment were important contributing forces in the creation of the culture which faced these computer science students.

Sproull, Zubrow, and Kiesler's (1986) research was an attempt to determine whether their 1982 analysis held for other settings and whether novice characteristics (gender, experience with computing before college, academic interests and abilities) affected the socialization experience. The research conducted in 1986 was designed to investigate how novice college freshmen encounter the culture of computing, and what is learned about computing and themselves as a result. Based on their research conducted in 1982, it was suggested that the process of initial socialization for these students had four major features: (a) reality shock, (b) confusion, (c) control attempts, and (d) initial socialization outcomes (positive and negative).

A nine item survey was conducted with freshmen at two universities in 1983 and 1984. Students answered the items for computer science and at least two other courses. In both universities computing was highly valued and technical subjects were emphasized. Both universities required freshmen to take a programming course. University A was a research institution with a well respected computer science department. University B was more professionally oriented.

Two items found significant differences in both years at both universities. For the reality shock item, a higher proportion of students felt that their computer science course was considerably different from other courses. Likewise, it was a significantly higher proportion of computer science students who felt that their computer science course made them angry. In at least one year at both universities significantly more students felt confusion in their computer science course than in their other courses.

Based on the three outcomes, pride, anger, and withdrawal, the researchers classified students as potential cultural recruits or dropouts. Consistent across both years at University A, three groups were more likely to be recruits in other courses and dropouts in computer science — nontechnical students, women, and students with no prior computing experience. At University A, women more often than men reported reality shock, confusion, control attempts, and anger associated with a computing course. Also at University A, students with no prior computing experience more often reported confusion in computing than students with prior experience.

These findings were all based on a limited questionnaire suffering the same problems as previously noted with questionnaire research. Consistent with the Sproull, Kiesler, and Zubrow (1987) research, however, this research also found that students characterized their computer science courses as being "very different" from other

courses. Students felt anger and confusion in their computer science courses more than in other courses. Also consistent with previous research, prior experience with computing helped to minimize confusion with computer science coursework.

Turkle (1988) was also interested in describing the culture of computer science and used an ethnographic and clinical methodology. Turkle's study involved interviews with 25 Harvard and Massachusetts Institute of Technology (MIT) women computer programming students. All of the women interviewed by Turkle were currently enrolled and succeeding in computer programming courses. Turkle's methodology appeared to be sound but the findings presented were supported by interview data from only two students.

Turkle (1988) found these women unafraid of the computer but hesitant to be involved with the threatening object and culture of computing. Though hackers, persons absorbed by their fascination with computers, were a minority in the computer culture, they were visible. Turkle made the argument with the interview data that when women see the hackers, women consider the importance of their personal relationships and define themselves as not belonging in this social structure.

The hacker's learning style was characterized by taking risks. Risk-taking developed understanding through initial immersion in the problem without understanding. Turkle (1988) stated that the women found it difficult to adopt the risk-taker's attitude and not take failure personally.

Turkle (1988) characterized most women's programming style as a relational encounter. Much like an artist, persons using this style manipulated computational objects with almost a tactile style. When used fluently, this approach was possibly a source of creativity. But women in Turkle's study commented that in order to be successful, they felt they needed to abandon this style. The women felt that in dealing with the machine they had to be persons who commanded rather than communicated.

One of the students was uncomfortable with formal systems that characterized work in mathematics and computer science. She was bothered by a highly structured formal system allowing only one way of doing things. She also saw people working with formal systems as those persons who talked to computers all day and did not relate to one another. Turkle (1988) argued that interactions with computers were less restrictive. Computing environments supported, via powerful and flexible programming languages, a variety of programming styles. The diversity of styles

supported by the computer led to a different type of relationship for every individual. But rarely in introductions to computer science was the process of computing presented in this light.

Turkle (1988) contended that those students with a more artistic/relational style (many women) were discouraged by the traditional course which espoused structured programming as the single right way of programming. These students were likely to dropout of computer science because they questioned their ability to do computing as they have been made to see it. Turkle suggested that women's experience with computing was totally different if the formal system were personalized — if women were allowed to experience the system in their own style.

Harrington's (1990/1991) research was designed to gather descriptions of women's experiences as they studied undergraduate computer science. Harrington called on her own experiences during four years as an undergraduate and three years as a teaching assistant as well as interviews with 22 women who were, or had been, students in computer science at her university. The subjects were described as "representative" but no description was given as to how the subjects were selected. The data may have been biased in subtle ways by the fact that interviews with the subjects ranged in length from half an hour to four hours. The assumption must be made that interview questions were not leading though the nature of the research itself may have led the women to be more negative in commenting on their experiences. Few positive experiences were reported.

The interviews were unstructured and points of discussion included, but were not limited to, classroom instruction, evaluation, laboratory setting, departmental policies, and interactions with people. Harrington (1990/1991) did ask questions about certain aspects not mentioned by the subjects. These topics included: first impressions of the computer lab and class, reasons for studying computer science, and descriptions of frustrating and/or encouraging situations.

The women were drawn to the study of computer science for a number of reasons. Among them were: encouragement by friends already studying computer science, desire for a well paying career, curiosity aroused by casual contact with computers, anticipation of a career that would accommodate flexible working environments and hours, and interest in using the computer as a tool for writing, artistic efforts, and other special interests.

The women recalled their first encounters with the computer science department. From the beginning they felt they did not belong. Department requirements and procedures were unclear and seemed to them to be designed not to help students but to serve as obstacles. Such difficulties were viewed as unusual by the women and were not expected. They quickly became aware that women were a minority within the department and began to question whether they really belonged.

As the women remembered their classroom experiences, they described feelings of self-consciousness as they took their place in large classes and looked around at how few females were among them. The women quickly discovered that though previous experience was officially not a prerequisite, it was an unofficial requirement and of the 10% of the students with no experience, many were female. After being told the first day in a computer science course that only one-third of the students would advance to the next course, failure to meet this unofficial prerequisite immediately put the women at a disadvantage.

Some of the women failed and repeated the first class. Some chose to repeat the course because they felt they needed to develop a better understanding of the material. The women who succeeded did so only by spending 20 to 30 hours preparing each week for this four credit course. Even the women with prior experience found the class to be "intense, stressful and isolating" (Harrington, 1990/1991, p. 104). The women felt that these feelings developed largely out of the fact that students were discouraged from working together and thus a competitive situation developed as students competed with each other for grades that allowed them to continue in the program.

The women also reported frustration with the presentation of material in the classroom. The women wanted to have more examples used in class and had difficulty with many of the examples that were used. Frequently the examples involved mathematics beyond the prerequisites of the course or were situated in domains unfamiliar to the women — contact sports, mechanics, or construction. Examples were sometimes incomplete or confusing and many times pictured men in positions of power while the women were in supporting roles. Programmers and computer scientists were almost exclusively referred to as "he."

Students were not encouraged to ask questions in class and only two of the women reported ever having done so. One woman felt that asking questions had

earned her respect while the other woman sensed annoyance from the instructor and experienced ridicule from other students. The women remembered many of the questions being asked by older males who sometimes seemed to be attempting to exert some control over the class. These questions intimidated the women and made the women with less experience even less likely to be heard. Many of the women kept silent throughout their undergraduate classroom experience because they feared they would appear stupid or show how little they knew.

The frustrations of the classroom only became worse as students moved to the computer laboratory. The commands required to function within the computing environment had to be used precisely and were difficult if not impossible to logically deduce. The women observed as well that much of the language used in the lab was offensive or showed its roots in military combat or male sexual experience — "my program bombed, execute the program, kill the process, abort the job, the machine is up, the machine is down" (Harrington, 1990/1991, p. 112).

Students were forced to work in this environment with only a cursory introduction that may have contained errors or was not applicable to the equipment used by the students. Completion of initial assignments required a huge investment of time after waiting a couple of hours for a machine to become available. The women without computer experience felt anxious working in the environment. They were afraid to do the requisite experimenting for fear they would damage the equipment or reveal their stupidity.

The women described the physical environment of the laboratory as composed of anxious people working frantically against a deadline in a crowded room that smelled like a locker room. The women felt that many of the men who spent considerable time in the lab "had no social skills ... and just acted bizarre" (Harrington, 1990/1991, p. 114). Students frequently needed to work in the lab late at night and some of the women reported receipt of pornographic messages on their terminals as they worked. The whole setting left the women feeling isolated, afraid, and extremely uncomfortable.

Comments were not positive in regard to the textbooks chosen for computer science courses. It was an exception for the textbook to be described as even fairly good. The women felt that the texts chosen were usually irrelevant to the material presented in class and, in any case, were difficult to read, contained many errors, were

at a level above the level of the course, and were sexist. Concepts rather than being clearly presented were made "abstract, vague and mysterious" (Harrington, 1990/1991, p. 116). The texts consistently referred to computing professionals as males and the women responded by feeling excluded or angry.

The picture of the women's experience did not improve as the women discussed their work on assignments and experiences with other forms of evaluation. Assignment specifications were usually typed but were described as vague and frequently in need of further clarification or correction. Changes and alterations were common but were communicated informally and often not discussed in class. The women were overwhelmed by the need to spend 15 to 20 hours a week on programming assignments. Much of the time was not spent dealing with the concepts to be learned but rather was spent trying to figure out what the assignment was while talking with the right people to get help.

Courses in the final two undergraduate years frequently required students to work in groups on projects. The groups of two to four persons were usually self-selected. The women commented that it was hard to deal with the fact that the experienced males stuck together and did not accept females in their groups. Group processes and participation were not monitored and a group grade was given to each individual in the group. Success required membership in a good group. The women reported difficulty working in groups with men. The women were frequently forced to take the role of a communicator and integrator of ideas as the men operated competitively and found it difficult to cooperate. Often the women found their problem solving approach to be entirely different from that of the men in the group. The women who had the opportunity to work in an all-female group reported that they much preferred the experience of working in a supportive and noncompetitive all-female group.

Comments from the women directed toward the mid-term and final examinations were extremely negative as well. The examinations were characterized as "far out ... [with] questions [that] were impossible to decipher" (Harrington, 1990/1991, p. 122). The women felt that the examinations did a poor job of measuring what they really knew. Frequently not enough time was available to complete the examination and the average grade on many examinations was as low as 30%. The women felt that this experience made many students feel badly enough to

quit even though a 30% may have been an A grade. They characterized the whole procedure as an "intimidation tactic" (Harrington, 1990/1991, p. 122).

Visits with professors during their office hours also intimidated the women. Since classes were large, a long wait was usually necessary before the professor was free. If they did talk to a professor, the students found professors to be "distant, . . . discouraging, and unhelpful" (Harrington, 1990/1991, p. 125).

As the women interacted with people in the computer science environment, they found these interactions to be guided by a positioning of people within a hierarchy. The women felt they stood out as a minority among the men and were not welcome within the hierarchy. Consequently, the women found the support they needed among themselves or with persons outside the computer science community. Forming these relationships and thus gaining access to information, for these women, was viewed as essential to survival.

While Harrington's (1990/1991) sample and Turkle's (1988) sample included only successful females, the data gathered in these studies, and the other "cultural" studies in this section, highlighted many barriers that further research may find to be consistent with the experience of students in other universities. This research collected data from teaching faculty and male and female students in computer science. Data collection for this research extended over six months and the data collection process, including researcher and participant involvement, was thoroughly documented. By its design this study overcame many of the problems present in prior research and made a significant contribution in the attempt to more completely describe how the existing computer science education culture operated and affected freshman students as they encountered the culture and tried to find their place.

Specific Factors That Influence Persistence

The Campbell and McCabe (1984) research is cited frequently in the research concerned with factors that affect persistence in a computer science major. Campbell and McCabe searched academic records in an attempt to identify characteristics of students who persisted through the first year of a computer science major.

The study was conducted at a large midwestern university in the Fall semester of 1979. The sample consisted of 256 first-semester freshman computer science majors who were enrolled in the first programming course for majors.

Third-semester data were collected from academic records for each student in the sample. The variables of interest were: SAT math and SAT verbal scores (200-800), rank in high school graduating class (percentile), size of high school graduating class, number of semesters of high school mathematics (6-12), number of semesters of high school science (2-12), number of semesters of high school English (6-9), average grades in high school mathematics, science, and English, and gender.

During their third semester at the university, the 256 students who entered as freshmen computer science majors were grouped into two categories: sophomore computer science or other science major, **CS+**, (N = 144) and other (other major or left the university, N = 122). The **CS+** group had higher SAT math and SAT verbal scores and higher high school math and science grades than the **other** group. After one year, 49% of the men and only 27% of the women persisted in a computer science.

In light of this gender difference in persistence, Campbell and McCabe (1984) compared means on the 10 variables between men and women. Men had higher SAT math scores even though no significant difference existed in number of semesters of high school math. The women had slightly higher high school math grades. The women's high school graduating class rank was higher and the women had higher high school English grades. The men completed more semesters of high school science.

Campbell and McCabe's (1984) persistence percentages for freshmen men and women have been broadly quoted in spite of the fact that little information was provided about the students involved, socioeconomic or educational background. In support of these findings, however, the research of Jagacinski, LeBold and Salvendy (1988) found similar percentages for persistence with a computer science major through the second semester of the sophomore year.

Jagacinski, LeBold and Salvendy (1988) conducted research to examine the extent to which precollege and college achievement measures predict persistence in various computer-related majors (computer science, computer technology, electrical/computer engineering, and industrial engineering). Since the interest of this

study was with the computer science major, only findings related to the computer science major were reviewed.

The subjects for the study were freshmen in 1980, 1981, 1982, or 1983 with one of the computer-related fields as a declared major. For the computer science major, 1445 students were included. Records were obtained from the registrar and information was gathered with regard to SAT math and verbal scores, high school grades and number of semesters in math, science, and English, high school rank, the student's declared major, and GPA for each semester in college. Persisters were defined as students whose major remained the same, freshman year through the second semester of sophomore year. The authors noted that most of the students who were classified as nonpersisters did not leave the university but rather changed majors to a noncomputer-related field.

A significant difference was found in persistence percentages for incoming freshmen computer science majors. A higher percentage of men than women persisted in the group of freshmen that began in each of the four years. The data overall found 52% of the men and 28% of the women to be persisters.

Means on the 10 variables for men and women persisters and nonpersisters were reported. Persister-nonpersister means were compared by gender and found significant differences for men on the variables SAT math, SAT verbal, high school grades in all three subjects, number of semesters of high school science, high school rank, and second semester GPA (in all cases persisters ranked higher). For women the persisters' means were significantly higher for the variables SAT math, SAT verbal, high school math grades, and second semester GPA.

The researchers wanted to identify other factors contributing to the pronounced differences between male and female persisters and nonpersisters in computer science. A survey was designed and sent to computer science students. Addresses for only 73% of the students were available; a low response rate (38%) was received for these students. Other problems were the self-report nature of the survey and the length of time that had passed since these students had made the decision to persist or not persist in the study of computer science. Noting these problems, the authors cautioned that the survey results could be considered interesting and might be helpful in guiding future research.

The survey found that women persisters were more likely than women nonpersisters to have had a definite computer-related career goal when they entered college. The women persisters also placed more emphases on enjoyment of problem solving and work with ideas. When making the choice of a major, women nonpersisters rated working with people and making a contribution to society as more important than persisters. Women persisters were more likely than men to mention the importance of the support of friends. Male and female persisters rated the course work as more interesting and enjoyable than did nonpersisters. For 86% of the persisters, the challenge of the work was an important factor in the decision to persist.

Teague and Clarke (1991) reported on a study designed to investigate the role false perceptions of a computer science career played in the underrepresentation of women in the field of computer science. Summary data from interviews with 34 male and 34 female undergraduate computer science students were reported. Also presented were five case studies from the student interviews and seven case studies from interviews with women who were currently employed in the computing industry.

The research design consisted of 34 interviewers each conducting two interviews. The interviewers conducted one interview with a male undergraduate computer science student and one interview with a female undergraduate computer science student. The interviewers were 34 final year social psychology students who were "provided with a guided interview schedule and detailed instructions" (p. 378). Although this research design had major weaknesses, the research did identify important questions and results consistent with other research.

Experience and access were found to differ between men and women. Men reported previous computing experience and access to a home computer more often than women. Consistent with other research (Clarke & Chambers, 1989) Teague and Clarke (1991) found men to have higher expectations and confidence when in fact no significant gender differences in academic results existed.

When asked to cite the major reason for studying computer science, women more than men cited good career prospects. On the other hand, more men than women made the choice because they liked computing. Women more often than men mentioned that they felt successful when they received good grades. Thirty percent of the men compared to 15% of the women said they had not had a failure in their computer science studies. The major problem for 50% of the students (70% of the

women and 32% of the men) was frustration with allocation of time necessary to complete assignments.

Five student case studies were presented to provide further evidence of computing attitudes and issues students perceived as important. Seven case studies of professional women were also presented. These professional women were asked about their current job, likes and dislikes of the job, and ideas as to why women are underrepresented in computing.

Teague and Clarke (1991) discussed some commonalities in the professional women's case studies. Several said they loved their jobs but did not like to program. This fact prompted the admonition to communicate to women students that computer science was not just programming (the typical student perception) and did not require special technical skills, skills that women typically considered to be men's territory. These professionals talked about work they enjoyed that was people oriented rather than technical, mathematical, or scientific.

All of the studies which follow in this review utilized a specially constructed questionnaire (with no reported validity or reliability) for data collection. The problems with this method have already been observed. Results of the research which follows should be considered in light of this methodological weakness.

Clarke and Chambers (1989) considered a large number of potential factors in research conducted at Deakin University in Australia. The research was designed to address two questions: (a) Are there differences between men and women on the factors of general academic ability, previous computing and mathematics experience, encouragement from significant others, the availability of male role models, generalization of attitudes to related areas, sex-typing of computing activities, beliefs in abilities, and attributions for success and failures; (b) do these factors influence decisions to pursue further computing studies and/or relate to achievement in computer science courses?

A questionnaire was completed by 110 men and 112 women (a 95% response rate) enrolled in a required statistics and computing concepts course at the university. The researchers indicated that the choice of a compulsory course was intended to minimize the effect of choice in the assessment of achievement related gender differences.

The questionnaire collected data on a variety of computing experiences. Men reported experience with more computer systems and more computer languages. Men had more experience than women with computing applications. More men than women also reported that they were the principal user of a home computer.

Students rated 13 computer-related occupations on a five-point scale. An occupation was considered to be sex-typed if the mean score differed from the neutral point. The men and women both sex-typed data entry operator and primary school computing teacher as female. Computing lecturer, computer salesperson, professor of computing, and computing center manager were sex-typed by both men and women as male. Additionally, men sex-typed computer operator as female and computer programmer, secondary school computing teacher, and systems analyst as male. Whether sex-typed male or female, the women's average score was always closer than the men's to the neutral point.

On all items related to course attitudes, significant differences existed between the men and the women. Women more often than men were enrolled in the course because it was required. Men were more confident in their ability to pass the statistics and the computing component. Likewise, a slightly higher proportion of men than women expected higher grades in the course. Even though men had expected higher grades in the course, no significant gender differences existed in the final statistics or computing grades in the course.

When factors for success in the course were rated, women gave significantly higher ratings than men to hard work, good teaching in class, and personal help from lecturers or tutors. Men rated personal ability as a factor for success significantly higher than women. Generally the women felt more strongly that course difficulty and personal lack of ability were contributing factors to failure in the course. These findings were consistent with gender differences reported by other research (Bernstein, 1991).

A regression analysis was performed to identify factors related to predicting academic performance in computing. The regression analysis identified three variables that accounted for 20% of the variance. The variables were computing experience (16%), mathematics experience (2%), and university entrance score (2%). When analyses were conducted separately for men and women, these variables accounted for

21% of the variance for men and only 7% of the variance in achievement scores for women.

Significantly more men than women planned to continue further studies in computing or to complete a computer science major. A regression analysis to predict intent to major in computer science identified four variables accounting for 42% of the variance. The variables were computing attitudes (31%), gender (7%), sex-typing (2%), and statistics attitudes (2%). The authors noted that experience (a significant predictor in achievement) and academic achievement did not factor into the decision to major in computer science. Separate analyses for women and men yielded no differences.

While the first impression may be that a large number of factors were considered, the most significant outcome of the Clarke and Chambers (1989) research was that even when considering this many factors, 79% of the variance in achievement for men and 93% of the variance for women remained unexplained. If interested in intentions to major in computer science, however, differences in achievement may be less important. Rather, 31% of the variance in the decision was accounted for by attitudes toward computing.

Ware, Steckler, and Leserman (1985) investigated factors in the college environment that affected students' academic major choices. Three hundred incoming freshmen (150 males and 150 females) were selected for the study. These students' college applications indicated an interest in majoring in science. (Science was defined to include physical science, biological science, mathematics, computer science, engineering, and premedical studies.) Conveniently, the SAT scores for the men and women were almost identical. Likewise, high-school preparation in mathematics and science was nearly equivalent for the women and men in terms of the number of courses taken.

The students completed questionnaires in the Summer prior to their freshman year and once each year during college. The questionnaires asked the students to provide information on personal background, college experience, choice of major, and plans for career. A portion of the sample (110 men and 107 women) also completed the Thematic Apperception Test (TAT) during the Fall of their freshman year. Finally, 20 women and 20 men were selected to participate in yearly interviews,

"designed to explore in greater depth aspects of concentration choice, career plans, and academic experience" (Ware, Steckler, and Leserman, 1985, p. 74).

In August of the freshman year, 90% of the group continued to consider a science concentration and by November the percentage was 81%. At the end of the freshman year a statistically significant difference existed between the percentage of women (50%) and men (69%) who declared a major in a scientific field — figures similar to those of Campbell and McCabe (1984).

The investigators used multiple regression analysis with a sample of 78 men and 85 women to test different factors as predictors for male and female students' choice of a science major. A significant positive factor for both men and women was a science course as a favorite of all courses during the freshman year. Highly educated parents were a significant positive factor for women and a significant suppression effect for the men. Additional factors selected as significant positively for men were: (a) high grades in freshman-year science courses; and (b) certainty about the choice of a major the Summer before entering college. Additional significant positive factors for women were: (a) high SAT math scores; (b) a need for power as measured by the TAT; and (c) a need for affiliation as measured by the TAT.

Of particular interest was the fact that 49% of the men and only 31% of the women reported a science course as the most enjoyable course during their freshman year. Since this factor was significant for both men and women (and one of the most important for women), further research is needed to identify differences in men's and women's reported experiences in the classroom and academic environment. The research presented here addresses this need to describe classroom and academic experiences.

Bernstein (1991) was interested in answering the question, "What produces comfort with computers and how is comfort related to computer achievement for men and women" (p. 57)? The study involved 25 women and 26 men enrolled in an undergraduate management science course which was the second in a sequence of computing courses. Though the Bernstein study focused on *computing* rather than *computer science*, it is included in this review because it raised "comfort with computing" as an important determinant of success with computing and suggests that women's initial contact with computing may establish their comfort level.

Measures of student comfort and experience were based on two questionnaires and a mathematics test. Additionally, the students were asked to design two spreadsheets; one spreadsheet merely required duplicating the design of a spreadsheet given to the students on paper; the other spreadsheet required analysis of a problem and design of an appropriate spreadsheet to solve the problem. The two spreadsheets were scored based on correct information, acceptable format, correct formulas, and flexibility.

Correlations for the men and women students were calculated for each pair of variables — comfort, prior spreadsheet knowledge, relevance, math score, and spreadsheet score. For both men and women, comfort level was significantly correlated with prior spreadsheet knowledge. Comfort was also correlated for women with the spreadsheet score. For men, spreadsheet score was significantly correlated with math score and relevancy. Both men and women felt the course was relevant to their future but for women this relevancy did not correlate with any of the other variables.

Bernstein (1991) reported some student comments with regard to comfort with computers (no description was presented of how the comments were obtained). Men attributed a low level of comfort to poor teaching methods or not enough practice. Women at the low comfort level felt others knew more and these women were intimidated when forced to share computers with others.

Men whose comfort level was high, attributed personal comfort to computing experience — having a computer at home or using a computer for many years. In contrast, women who were highly comfortable with computers talked about positive experiences with computing — the computer is helpful, computing is enjoyable, the computer has not given any trouble yet. Thus, women's initial contact with computing may be a key factor in establishing comfort level and comfort level for women may have a significant effect on future success with computing as indicated here by correlation with spreadsheet score.

Lips and Temple (1990) attempted to develop a model to describe the factors that influenced the decision to major in computer science. The model was based in expectation × value theories of achievement behavior and included factors identified in the literature previously reviewed.

Models for academic choice based on expectation × value theories have been successfully developed by others for other applications. Expectation × value theories link the motivation for achievement to perceived value of success and expectations for success. Related to perceived value of success, Lips and Temple (1990) included the factor, interest in and enjoyment of computers and computing. Related to expectations for success were factors of confidence with respect to mathematics and computing. The fourth factor, computer experience, was included because of the evidence in the literature that this "reality check" was an important element of academic choice for computer science and operated differently for females than males. Once the model was developed, Lips and Temple predicted that the model described both males and females but that females had a stronger link between computer science experience and computer interest and enjoyment.

A questionnaire was completed by 305 students (178 females, 127 males) enrolled in introductory psychology and sociology courses. The authors reported that most of these students were in their first or second year at the university and were not yet committed to a major. No further description was given of the university or the subjects.

The computer software, LISREL VI, tested the model, calculated regression coefficients between each of the variables, and provided goodness of fit statistics to help describe the fit of the data with the model. Analyses for the female subjects found a reasonable fit for the model. The squared multiple correlation indicated that only 18.8% of the variance in women's intent to major in computer science (IMCS) was accounted for by the model. The fit for the male subjects was not as good but similar. However, the model did account for 31.3% of the variance for the men's IMCS.

In order to assess where the differences in the model occurred for males and females, *t*-values for the coefficients between variables were computed. Significant for women but not for men were mathematical ability (MA) to comfort with computers (CC) and computer science experience (CSE) to interest and enjoyment of computing (IEC). MA to IEC was significant for the men but not the women. Significant for both men and women were: MA to IMCS, CC to CSE, CC to IEC, and IEC to IMCS.

Based on relative sizes of the coefficients, for men the decision to major in computer science appeared to be based largely on confidence in mathematical ability

and comfort (confidence) with computing. For women, on the other hand, the largest contributors to the decision were CC and IEC.

Though the model left much room for other factors to predict the intent to major in computer science, some relationships of interest were highlighted in the research. Once again the importance of computer science experience in shaping women's interest in computing was indicated. And, women's interest in and enjoyment of computing was found to be a significant factor in the decision to major in computer science. The decision for men was predicted to be largely based on confidence in personal abilities.

Much of the research that looked at differential enrollment and persistence patterns for women in engineering and computer science examined factors related to ability and achievement. Arguing that people's perceptions of their abilities are likely to influence career choice and preparation, Miura's (1987) research was designed to investigate differences between men and women college students in perceptions of self-efficacy regarding computer-related activities.

The sample consisted of 104 males and 264 females enrolled in a lower division interdisciplinary course taught at a large, urban university in California. A questionnaire was designed to assess self-efficacy in three sections containing five tasks where the tasks were listed in order of difficulty. Subjects checked whether they felt they could perform each task. For each task checked, the subjects then rated, on a scale of 10 (not very confident at all) to 100 (completely confident), personal confidence in ability to complete the task.

Statistically significant correlation (but with $r < .40$) existed between the composite self-efficacy score and plans to take a computer science course, perceptions of the relevance of computing skills for a future career, and interest in knowing more about how computers work. Not surprisingly, completion of a high-school computer programming course, and current and past enrollment in college computer science classes, were also positively correlated to the self-efficacy scale. ANOVA comparing male-female mean scores found men rated themselves higher than women on the self-efficacy scale.

For men and women combined, regression analysis found that gender, college major, computer ownership, high-school computer programming course, past enrollment in a college computer science class, and current course enrollment

accounted for 27% of the variability in the self-efficacy scale. The main predictors for women were high-school programming course, college major, past enrollment in a computer science course, and computer ownership. The predictors for men were the same with the exception of computer ownership.

In another study with a focus on prior experience, Kersteen, Linn, Clancy, and Hardyck (1988) attempted to determine the possible interaction of gender, prior computing experience, and computer science course performance. They hypothesized that prior experience with computers served as a predictor of college computer science course performance.

Subjects were students enrolled in the Fall or Spring semester of an introduction to computer science course. Students who successfully completed the course were permitted entrance into the computer science major. The authors reported the course to be extremely challenging — presumably the course was the freshman "weeding out" course for computer science majors.

A questionnaire, apparently consisting of 20 yes/no questions related to previous computer experience, was designed specifically for this research. Alpha reliability for the questionnaires were reported to be .81 in for the Spring and .83 for the Fall.

The researchers selected 13 of the experience items from the questionnaire to comprise a scale (with no explanation of the item selection criteria). "This scale was then used in a step-wise multiple regression equation to predict final grade" (Kersteen, Linn, Clancy, and Hardyck, 1988, p. 327). ANOVA found significant gender differences in the mean experience scale scores for both Spring and Fall semesters (indicating that the men had more experience). The resulting multiple R^2 for the men accounted for 14% of the variance in the Spring semester and 25% of the variance in the Fall semester. Though these numbers were not high, in contrast to the prediction power for women (R^2 = .0002, Spring; R^2 = .04, Fall), the difference was of potential interest.

The authors briefly reported on interviews conducted with two females and two males. A limited sample was acknowledged and no description was given as to how these four subjects were selected or how well they represented the populations. In spite of these methodological weaknesses the interview data did suggest the apparent

importance of support and encouragement from family and fellow students for women (and not men) in computer science.

Discussion and Conclusion

The enrollment data have produced computer science major persistence figures which quantify an already apparent problem: (a) Campbell and McCabe (1984) — persistence after freshman year — men, 49%, women, 27%, (b) Jagacinski, LeBold, and Salvendy (1988) — persistence through three semesters — men, 52%, women, 28%, and (c) Ware, Steckler, and Leserman (1985) — persistence in a scientific major through the freshman year — men, 69%, women, 50%. With recognition of the disproportionate female-male enrollments in computer science courses, research has attempted to identify factors and influences responsible for perpetuating the problem. While research in this area has investigated a wide range of factors, little about the decision to major and persist in computer science has been explained. Much of the research has suffered from methodological problems or has attempted to measure poorly defined, recondite social and personal constructs as isolated factors. In spite of these problems, past research did provide direction and suggest questions that guided this research study in a description of the experience of freshman computer science students as they encountered the culture of undergraduate computer science education.

Several of the studies raised the question of the role of achievement in persistence decisions (Clarke & Chambers, 1989; Jagacinski, LeBold & Salvendy, 1988; Ware, Steckler & Leserman, 1985). Comfort and feelings of self-efficacy were found to be important factors in women's decisions to study computing (Bernstein, 1991; Lips & Temple, 1990; Miura, 1987). Many of the studies highlighted the importance of prior experience and the significance of initial contact with computing in the decision to persist with a computer science major (Bernstein, 1991; Clarke & Chambers, 1989; Harrington, 1990/1991; Kersteen, Linn, Clancy & Hardyck, 1988; Miura, 1987; Sproull, Kiesler, & Zubrow, 1987; Sproull, Zubrow & Kiesler, 1986; Teague & Clarke, 1991).

Perception of computer scientists and a computer science career was also found to play a role in the decision to major in computer science. The image of the hacker and the hacker's intimate relationship with the computer discouraged women from

becoming involved with computing (Turkle, 1988). The hacker image led to the perceptions of a career in computer science as hours spent in front of a machine doing programming. Women saw the hacker as the typical computer scientist and did not want to be recognized as "one of them." Teague and Clarke (1991) found that professional women in computer science wanted to emphasize to undergraduates that they loved work in computer science but did not like to program. Rather, these professionals enjoyed the people-oriented aspects of their career.

The research highlighted a number of influential factors developing more directly out of the culture and environment surrounding computer science education. When women began academic work in computer science, they immediately noticed that the culture of academic computer science was dominated by males (Rasmussen & Håpnes, 1991). The women quickly developed a feeling that women did not belong. The women's minority status made them feel uncomfortable asking questions in class (Harrington, 1990/1991). And, as the men in the class asked questions, many of the women noticed that women brought different concerns, priorities, and goals to the study of computing than those typically rewarded by professors and held by the male majority (Rasmussen & Håpnes, 1991).

As Sproull, Kiesler, and Zubrow (1987) and Sproull, Zubrow, and Kiesler (1986) found, students recognized that computer science courses were much different from other courses. Students must not only learn computer science but must also learn how to learn computer science. Consequently, Sproull, Kiesler, and Zubrow (1987) and Sproull, Zubrow, and Kiesler (1986) found that students reported anger and withdrawal in response to computer science courses much more often than for other courses.

In addition to the unfamiliar and potentially frustrating nature of computer science courses in general, the typical environment of computer science education was described as competitive and individualistic. Many women found it difficult to succeed in this type of environment, an environment preferred more by men than women (Harrington, 1990/1991; Sproull, Kiesler & Zubrow, 1987).

Many of the studies identified factors relating to the conflict of styles as women attempt to succeed in the traditional structure of computer science education. In this environment professors and teachers generally characterized a good computer science student as one who was a risk-taker absorbed in work (Rasmussen & Håpnes,

1991). The hacker's style of learning was difficult for women (Turkle 1988). Likewise, many women found structured programming (the programming style espoused as the right way of doing things) to be uncomfortable and in conflict with a naturally artistic and communicative style (Turkle, 1988).

Finally, as women went to the computer laboratory to complete homework assignments (another unique feature of computer science courses) additional obstacles faced them. Bernstein (1991) found women to be intimidated when forced to share computers with others. Students commented that the terminal room was unpleasant and the women worried about what people working around them might think as they struggled to solve problems (Sproull, Kiesler & Zubrow, 1987). Lack of experience meant that women had difficulties dealing with the computer operating system. These difficulties proved to be a significant obstacle to successful completion of the course (Harrington, 1990/1991; Kersteen, Linn, Clancy & Hardyck, 1988). The formation of supportive relationships and the help of others thus became essential for the women's survival in computer science courses (Harrington, 1990/1991; Kersteen, Linn, Clancy & Hardyck, 1988).

In addition to the methodological problems, one of the frustrations with some of the current research is the focus on factors such as past academic achievement, support of family, and prior experience. Once women become undergraduate students, these factors cannot be changed. Much of the research has been limited by the research question and focused only on the experience of women. Description of men's experiences in the study of computer science and the inclusion of the influential faculty perspective would more completely describe how the culture developed, operated, and affected *all* members of the culture. An examination of factors in the current experience of undergraduate students (women and men) that encourage good students to persist or not persist, factors which could be affected to improve the situation, is more helpful.

CHAPTER III
DESIGN AND METHOD

Introduction

The review of the literature highlighted the problems with a traditional questionnaire approach to research designed to assess how students experience different factors in the culture of undergraduate computer science education. This research borrowed ethnographic techniques and was of a qualitative, descriptive, and ethnographic nature. This type of research best describes the factors that shape the culture of computer science and how individual students respond to these factors *over a period of time* during their academic experience. This descriptive research included the experience of male and female freshman students within the culture as they shaped the culture for themselves and each other over the course of the first two school terms in their undergraduate experience. Existing research has suggested that the professor's classroom conduct, expectations, and structure of assignments and assessment have a major impact on shaping the culture and experience of the computer science student. Perceptions and perspectives of faculty must be a part of a complete description of the culture and were included in this study.

A rich cultural description was developed in this research through three sources of data, interviews (semi-structured and informal), written journal comments, and observations. Complete descriptions of the research method, the research participants, data collection and method of analysis are included in this chapter.

Method

Peshkin (1993) has commented that quality nondescriptive and prescriptive research depends on the "accuracy, sensitivity, and comprehensiveness of its descriptive foundation" (p. 24). The review of the research available revealed that the design of any intervention or change attempting to improve the gender balance in the field of computer science rested on research that provided possibly distorted or misleading information about the operation of isolated factors in a complex,

interrelated cultural setting. This research provided indepth and accurate knowledge of the experience of freshman computer science students at one university thereby granting a new perspective on the situation. With the contribution of this broadened perspective, this research provides a basis for subsequent research focused on improvements in computer science education for all students.

Qualitative and ethnographic methods supported this attempt to study a truly complex situation. Peshkin (1993) cautioned that traditional quantitative methods are inadequate when the research relates to people, events, and situations which involve more interrelated variables than any one study can expect to handle or operationalize. Diverse and rich data are required in a study that attempts to capture the complexity and variability of human interactions in their natural setting (LeCompte & Preissle, 1993).

The method of this research drew on the strengths of the ethnographic tradition. Internal validity was strengthened by an extended period of time in the field (Fall and Winter terms) thereby enabling the research to more completely capture the participants' perspective (Eisenhart, 1988). By inclusion of the subjective experiences of both participants and researcher into the research frame, ethnography provided a depth of understanding often missing when other approaches guide the research (LeCompte & Preissle, 1993). Eisenhart suggested that the researcher can make sense of the world from the perspective of the participants through involvement in the situation as an insider and reflection upon these experiences as an outsider.

Wolcott (1985) maintained that culture can never be observed directly. The best any research can hope for is to infer culture by adopting an overriding concern for context and a focus on the perspectives, meanings, and interpretations of individuals in their world. Important to the conduct of this research, was Wolcott's (1988) caution to allow those persons in the setting to reveal their perspectives on their world rather than producing an account where the researcher serves as interpreter for the participants.

Many forms of data collection (interviews, observations, and written journal comments) were utilized so that data collected by one method could be used as a check of the accuracy of data gathered in another way. LeCompte and Preissle (1993) stressed the importance of multiple forms of data. "Triangulation prevents the investigator from accepting too readily the validity of initial impressions; it enhances

the scope, density, and clarity of constructs developed during the course of the investigation. It also assists in correcting biases that occur when the ethnographer is the only observer of the phenomenon under investigation" (LeCompte & Preissle, 1993, p. 48).

The nature of this research put the researcher in a position of examining an educational setting that was familiar and commonplace to the researcher. The challenge for the researcher was to engage in a process of examination of the commonplace in an original and different way, to treat situations as if they were unique and unusual. The researcher attempted to enter the setting as if it were totally unknown. Erickson (1973) called the process *making it strange.*

These concerns guided the design of this research and continued to guide the research as it was conducted. The research was meant to be a synthetic and holistic activity true to the context of undergraduate computer science education. Such an approach to the research yielded the richness of data necessary to support a thick description of the culture of undergraduate computer science education and the experiences of freshman students as they encountered that culture.

Participants

This study was conducted at a major land grant, research university I (Carnegie classification), hereafter referred to as the University. The study was conducted within the computer science department and first two courses in the freshman computer science sequence (CS 101 and CS 111). Because the nature of the research necessitated regular researcher involvement in the setting, the University was selected based on convenient location to the researcher's residence. Approval of the department chairperson, head undergraduate advisor, and course faculty were obtained before the study was initiated.

The first course in the sequence, CS 101, was a computing course and not a computer science course. CS 101 was a departmental service course for the University and, therefore, some of the students enrolled in the course were computer science majors and some of the students were non-majors. Incoming computer science majors with previous computing experience could choose to not enroll in CS 101 but all

students were strongly encouraged to complete CS 101. CS 111, however, was a required course for all computer science majors. This course was designed to present the student with a broad overview of many topics in computer science and was recognized as a course that "weeded out" many computer science majors at the University.

Key Informants

The perspective of faculty members is integral to a portrait of how the culture of computer science education develops and affects students. During the Summer of 1993, the faculty for both of the courses were contacted to obtain their written consent to participate (see Appendix B).

The University operated a Summer program of orientation and advising for incoming students. From this program the computer science department received names and addresses of enrolled freshmen who identified themselves as computer science majors. This information was made available to the researcher to solicit volunteers willing to be contacted on a regular basis to contribute information about their computer science education experiences. A mailing was sent to all participants in the Summer advising program who planned to enroll in CS 101 and CS 111 in the Fall and Winter terms of the 1993-1994 school year. The mailing included a letter that presented the research (Appendix C) and a postcard for students to return if they were interested in participating in the research.

In the first week of August the mailing was sent to the 29 incoming freshmen who had identified themselves as computer science majors when they attended one of the University's Summer orientation and advising sessions. Four of the students included in the mailing were female and 25 of the students were male. From the response cards of those persons willing to volunteer, it was hoped that three male and three female key informants would be randomly selected, however, postcards were returned by no females and seven males.

Persons who returned postcards but were not selected to participate were notified by mail. Persons selected as key student informants were contacted by telephone to provide the students a chance to ask questions and clarify their involvement in the research. Key informants were then mailed the Informed Consent

Form (Appendix A) and the form that was to be completed to establish their electronic mail account. The completed forms were returned to the researcher two weeks before Fall term began.

Three male participants were selected by random draw from the cards returned. The researcher then called each of the potential participants to answer any questions they had about the research, to confirm their willingness to participate, and to check that they planned to enroll in the Fall quarter course, CS 101, and the Winter quarter course, CS 111. When contacted one of the males indicated that he had taken a number of college computer science courses while he was in high school. Obviously this student's experiences in introductory college computer science courses was not typical, therefore this student was excluded from participation in the study. From the returned postcards another male was selected to replace the excluded male.

Because none of the four females returned postcards, telephone contacts were required. Before the researcher made these contacts, enrollment data were consulted to obtain phone numbers. For one of the four females enrollment data revealed that she had been conditionally admitted to the University and was required to be a part of a special program for academically questionable students. The determination was made to exclude this female from possible participation in the research because she might need to deal with additional obstacles in her academic endeavors and she was to receive special academic support. When contacted by phone, one of the three remaining females indicated that she did not have the necessary high school mathematics preparation so she did not plan to enroll in the Winter CS 111 course. The remaining two females planned to enroll in CS 101 and CS 111 and both agreed to participate in the study.

In an effort to balance the numbers of males and females involved in the study, three each, the researcher also followed up on the three female freshman computer science majors who came to the computer science department for advising the day before classes started in the Fall. These seven students were the entire population of incoming female freshman computer science majors. None of the three females contacted at the start of school were able to participate in the study. One of the students did not have the necessary mathematics background to take the Fall mathematics course (elements of discrete mathematics, MA 201) which was a prerequisite for enrollment in CS 111. The second student was a foreign student with

her own obvious additional cultural adjustments to make. The third student was apparently not enrolled for a full load. This third student was also a recruit for the University's basketball team and during advising had exhibited a negative attitude towards academics (according to the head undergraduate advisor). It was determined that this student's basketball commitments and attitude towards academics would significantly cloud the picture of her computer science experiences so this student was not included in the study.

Other Participants

The nature of the research presented the opportunity for all persons enrolled in the two courses of interest to participate in the research through informal interviews or conversations that arose naturally as the researcher was a part of the setting. The researcher (and the research) were introduced in the first class session in the Fall term course (CS 101) but were not introduced until the third week of class in the Winter term course (CS 111). It was made clear at this time that the researcher would be making observations in class and in the laboratory. The class was also informed that everyone was welcomed and encouraged to talk to the researcher and that their comments would be held in strict confidence.

The involvement of the researcher undoubtedly affected the context of the research in undetermined ways. This acknowledged participation of the researcher in the research provided important data as to how persons reacted to the researcher and how the researcher reacted to the people and the setting.

Data Collection and Analysis

Grounded theory research principles were a part of the framework for this research. Research describing the complexities of human social situations derives theory generated from that world. The researcher goes to the participants in order to gather data to support the inductive development of theory leading to an understanding of the participants' perspective in the situation.

Initial data collection was guided by questions raised in the previous literature such as the importance of prior experience with computing and perceptions of the nature of computer science education and a computer science career. Data collection was extended over the course of two academic terms to capture any development and change of perceptions over time as opposed to simply a snapshot in time.

Data collection occurred concurrently with initial data analysis. Codes for data, questions of clarification, agenda for interviews, and the focus of observations evolved throughout the time in the field as a result of observation and inquiry. Hutchinson (1986) contended that "the grounded theory method requires that the researcher simultaneously collect, code, and analyze the data from the first day in the field" (p. 61). Wolcott (1985) suggested that "data and interpretation evolve together, each informing the other. Additional data provide illustration, test the adequacy of the developing account, and suggest avenues for further inquiry" (p. 189).

Concurrent evolution of data and interpretation necessitated the use of *theoretical sampling*. The researcher not only searched for data matching evolving categories and codes but also sought contradictory data by finding and examining unusual situations and contradictory cases. This constant search for contrasts and comparisons in the data was the researcher's check on validity.

The use of a variety of methods for data collection was useful in providing differing perspectives on the topic of interest while attempting to capture the complexity and context of the situation. Each of the data collection methods is described below in detail. Data consisted of weekly observations in the classroom and in the computer laboratories, interviews (semi-structured and informal) with students and faculty, and weekly written journal entries submitted via electronic mail to the researcher by students and faculty. As Spindler (1982) cautioned, every effort was made during data collection to disturb as little as possible the communication and social interactions within the research setting.

Interviews

Three semi-structured interviews of approximately 40 minutes in length were conducted with each key informant, one before the start of the Fall term, one during

the first week of Winter term, and one after Winter term. These interviews were audio-taped and transcribed to insure that all information was captured accurately. The intent was to interview each course instructor twice, once before and once after the term in which he taught. These interviews were conducted with the Winter term course instructor. The Fall term instructor, however, failed to make himself available for the second interview so the only available interview data was from the interview conducted before the course began.

The first interviews with the students were scheduled at the time electronic mail training was conducted with key student informants. Students unable to attend the training were contacted by telephone. Interviews with faculty were scheduled at the time they signed the Informed Consent Form (Appendix B). The initial interviews with the students and faculty were relaxed and informal with the most important goal establishment of trust and comfort with the researcher. These informants were the primary source of data for the research. It was important to establish a level of comfort with the research (and the researcher) so that the informants felt comfortable as research participants sharing information about their personal experiences and perceptions. Subsequent interviews were also semi-structured and relaxed. The researcher raised questions of interest as such questions naturally arose within the course of conversation.

Though questions arose differently in each interview, questions in the initial student interviews solicited information concerning (a) factors perceived to have influenced the student to choose to attend school at the University, (b) factors perceived to have influenced the decision to major in computer science, (c) educational background, (d) past experience with computing and computer science, (e) expectations for personal success and difficulty with coursework in computer science and in general for their college experience, and (f) perceptions of a computer science career and appealing work in the field of computer science. Initial faculty interviews addressed (a) teaching experience and educational background, (b) goals for the course, (c) expectations for work required for a student to succeed, (d) perceptions of the capabilities of the student population enrolled in the course, and (e) teaching philosophy for the course. Questions in subsequent student and faculty interviews followed the same points of interest as in the first interview but were guided by the ongoing research and the developing theory.

Informal interviews or conversations were a natural component of the research as the researcher was engaged in observations as a regular part of the classroom and laboratory scene. These conversations with students and faculty provided an opportunity for the researcher to learn about experiences significant to students and faculty. Such conversation was also an opportunity for the researcher to check developing understandings of the situation with the participants. Written notes and mental recollections were recorded by the researcher immediately following these conversations.

Journals

Weekly journal entries were to be submitted by the key informants via electronic mail (e-mail) to the researcher. Students were introduced to the e-mail system and trained in its use in a training session the researcher conducted before classes started. In the weekly journal entries informants were asked to reflect on experiences of the week and to share their perceptions of how life as a computer science major was going for them. Occasionally, the researcher asked for clarification and checked emerging hypotheses and understandings. This weekly information from faculty and students guided observations and suggested questions for the research.

E-mail is an inescapable part of the culture of computer science education and the key informants were introduced to this facet early in their undergraduate career. The e-mail format offered certain advantages for this research. First, the researcher was able to check that entries were made on a regular basis by all informants. Second, this written format was more comfortable for those persons not comfortable discussing their personal experiences in a face-to-face interview. Third, e-mail offered the potential for interaction and discussion desired by some participants. Fourth, knowledge of the use e-mail gave the informants an additional option for "conversation" with the researcher. E-mail was checked at least twice daily by the researcher. Journal entries were transferred immediately to a file on the researcher's personal computer and deleted from the researcher's e-mail account.

Borrowing from the ethnographic tradition, the researcher also kept a daily personal journal of reflections on the research activities and context. These data made the researcher's role in the research more explicit and documented the development of

the research and the emerging theory. The journal included thoughts, questions, reactions, interpretations, insights, and decisions made in the course of the research process.

Observations

Observations were used to corroborate what people said they did (in interviews and journals) with information about what people were observed to do. In an attempt to be true to the context of the participants' experience and to capture the participants' perspective as completely as possible, the researcher attended every class session to make observations regarding course content, presentation, and materials, and interpersonal interactions. Observations in the laboratory occurred at least once a week at various times during the day and on occasion were timed to observe lab use immediately preceding assignment due dates.

The goal of the observations was to record phenomena relevant to the topic and current questions, to remain open to new topics and questions, and to document what has been omitted and why. Observations were conducted within the cautions of LeCompte and Preissle (1993) and Wolcott (1988). LeCompte and Preissle recognized that no observer can observe everything that is happening in a single group scene. On the other hand, Wolcott (1988) cautioned researchers of the tendency to oversimplify and reduce the complexity of the situation.

Observations were generally guided by interview and journal data and the developing framework of the research descriptions and theory. Field notes included quick notations as prompts for ideas to remember, transcriptions of comments when possible, and description forming as complete an account as possible of whatever was observed. Wolcott (1988) observed that the researcher's consistent presence provides the opportunity to continually ask questions and to learn what questions to ask. Guided by Wolcott's observation, field notes also contained ideas for further investigation, questions to follow up in interviews or journals, and notes regarding features to observe in the future. Field notes were elaborated and transferred to a computer file on the same day as the observations were made.

The researcher's role was that of a privileged observer and every effort was made to capture the scene as it occured in the experience of the participants. Every

attempt was made to bracket researcher biases. Maintenance of the researcher journal assisted the researcher in maintaining the proper focus.

The Researcher

The research design was predicated on the personal involvement of the researcher as the principal data collection instrument. The researcher recognized the importance of acknowledging personal experiences, training, and commitments which may have impacted the research. In acknowledging such factors, sources of potential bias or distortion were made clear. As Harding (1987) argued, by making the beliefs and behaviors of the research open to critical scrutiny, this "subjective" element improved the objectivity of this research over "objective" methods of other research which failed to recognize such information.

The researcher completed her undergraduate training in a small college environment (approximate enrollment of 400 students). In this supportive environment the researcher never felt discriminated against as a woman. The researcher completed majors in the physical sciences and mathematics (male-dominated fields) yet chose to enter the female-dominated profession of education. After teaching secondary school mathematics and science and undergraduate computer science for seven years, the researcher returned to the role of student as a graduate student enrolled in courses in the computer science department at the University.

As the researcher observed the minority status of women in her graduate computer science courses, she began to review the literature questioning the disproportionately low number of female computer scientists. The research question developed from the conflict between the researcher's philosophy that all persons are capable of making significant contributions and the question of whether the researcher's past teaching methods had discouraged capable women (and men) from persisting in a computer science major.

Because researcher interpersonal interaction is an integral component of grounded research, researcher behavior became data combined with the data from the research participants. To help bracket personal values and document the researcher's role, the researcher kept a daily journal of personal questions, reactions, and decisions. By acknowledging and bracketing personal preconceptions, values, and beliefs, the

researcher was able to transcend personal biases to develop an understanding of the setting from the participants' perspective and reflect on such understanding with awareness of other systems and theoretical perspectives.

Data Analysis

Data analysis was guided by suggestions from Bogdan and Biklen (1982), Hutchinson (1986), and LeCompte and Preissle (1993) for organizing and managing the collection of data and proceeding with categorizations for the data as data analysis and data collection occured simultaneously. Initially data analysis involved a search for similarities, regularities, and patterns which occurred frequently in each of the three sources of data. Words or phrases which represented these patterns and regularities were used to code categories. Each sentence and each incident was coded into as many codes as possible in an effort to develop theory capturing all of the data. The constant comparative method and theoretical sampling further defined, modified, and delineated categories as the research progressed.

According to Hutchinson (1986), the fundamental method of data analysis in the generation of grounded theory is the *constant comparative method.* LeCompte and Preissle (1993) provided the following description of the constant comparative method:

> This strategy combines inductive category coding with a simultaneous comparison of all social incidents observed and coded. This means that as social phenomena are recorded and classified, they also are compared across categories. Thus the discovery of relationships, or hypothesis generation, begins with the analysis of initial observations, undergoes continuous refinement throughout the data collection and analysis process, and continuously feeds back into the process of category coding. As events are constantly compared with previous events, new typological dimensions as well as new relationships may be discovered. (p. 256)

Following the suggestion of LeCompte and Preissle (1993), early data collection and analysis searched for similarities within the data which defined how categories were used and identified the attributes of each category. Later phases of data collection and analysis focused on differences among data items (and instances

where the data sources yield "conflicting" information) in order to encourage further definition of category attributes and establish boundaries between categories.

Wolcott (1985) observed that culture may be revealed by what people do or what they say they do. It is expected that people will not always *do* as they *say*. College freshmen have two main objectives during their freshman year: to succeed academically and to succeed socially (Erickson & Strommer, 1991). The bias of this research was that true feelings and perceptions were most likely expressed by what people said in private conversation and that pressures to succeed socially mitigated on occasion how personal feelings and perceptions were displayed in actual behavior. Preference was given in this instance to journals and interviews (what people said) in definition of categories. Observation data (what people did) were used to support what people said, to test what people said, and to further define conditions for categories of behavior.

As theory and categories developed from the data, the emerging research findings were also tested and refined through theoretical sampling and a search for positive, negative and discrepant cases in the three sources of data. Positive instances across the data sources helped validate constructs and theory. The search for negative cases focused analysis on data which contradicted the emerging theory. Such data helped to establish and further define parameters of constructs and highlight potentially invalid constructs. Isolation of negative cases also guided delineation of conditions and circumstances where a construct was applicable. Data not completely explained by the theory, discrepant cases, suggested modifications of a construct and indicated limitations in the explanations offered by the theory. An intentional search for positive, negative, and discrepant cases within the data served as a check of theory validity and ensured that the resulting theory was true to the context and data of the research.

CHAPTER IV
ANALYSIS OF THE DATA

Introduction

While data analysis evolved concurrently with data collection, the researcher was a part of the setting and experience of the research participants. The reader of this research must come to some analysis of the data based solely on a textual account of the research. The reader's representation of the participants' experiences, derived from rich descriptive data, is the support for a thoughtful analysis. Because analysis must follow from a clear understanding of the data, presentation of the data is separated from data analysis in the organization of this chapter.

Description of the research setting and general student experience includes course instructor and researcher experiences and perspectives. The question of interest, however, is the student experience and resultant decisions of persistence in computer science. Accounts of student experiences follow description of the overall research environment. Analysis of each student's experience immediately follows the chronicle of her/his experience. Because data collection resulted from the researcher's immersion in the setting, the research account contained in this chapter was written in first person.

The Participants

Each of the course instructors, for CS 101 and CS 111, was interested in the potential outcomes of the research and was a willing participant. The instructor for CS 101, Aaron, was a graduate student in the computer science department. Rick, the instructor for CS 111, was an instructor with faculty rank in the computer science department. Rick had been my instructor for two courses when I was a student. Rick knew me from these courses and I felt he respected my work as a student. Rick was also the head undergraduate advisor so, before the study began, I talked to Rick as I sought the cooperation of the computer science department.

All five student participants were 18-year-olds who had graduated from high school in the Spring of the Fall research year. The three male student participants, Trent, Devon, and Eddie, had each indicated their interest in participation by return of postcards included in the summer mailing that invited participation in the research. When contacted by telephone, each of the three male students was, without hesitation, happy to be involved in the research.

The two female student participants, Heather and Samantha, were contacted by telephone because no females returned postcards from the summer mailing. Heather quickly indicated that she had forgotten to return her postcard but wanted to be involved in the research. Samantha remembered receiving the mailing and was interested in the research. She wanted to hear more about the research. Upon hearing a description of the research, Samantha wanted to be a part of the research.

The Setting

University Programs for Students

The year in which the study took place was the second year for the University's Women in Science and Engineering (WISE) program. The WISE program was an attempt to support and encourage female students in science and engineering. One facet of the program was that one wing of a campus dormitory (dorm) was designated as living space for women students in science and engineering. One room of the dorm wing was set aside as the resource room and contained two computers. Twenty-five women resided in this wing of the dorm, 22 freshmen, one sophomore, and two seniors. One of the seniors was the peer advisor for the wing. Heather and Samantha both lived in the WISE dorm wing.

Each of the student participants in the study also participated in the University's summer orientation and advising program. As a part of this program the students spent one day on campus for general orientation and enrollment advising based on their chosen

major. Student research participants had all indicated computer science as their major. During their day on campus for summer orientation and advising, students met individually for 30 minutes with the head undergraduate advisor for the computer science department, Rick, the instructor for CS 111. During the 30 minute advising meeting, Rick answered student questions, explained course requirements, and assisted students in completion of the necessary enrollment forms.

All of the students in the study were enrolled during the Fall term for CS 101 and a discrete mathematics course, MA 201. CS 101 and MA 201 were both required for completion of a computer science major at the University. MA 201 was a prerequisite for the Winter term course, CS 111. Following successful completion of the Fall term courses, a freshman computer science major at the University was expected to enroll for CS 111 and MA 202 in the Winter quarter. Anticipated Spring term courses included the first course in calculus, MA 211, and CS 112, the continuation of CS 111.

CS 101 was a general introduction to computers, their applications and societal and ethical implications. The course was a general university service course offered by the computer science department but required for computer science majors because of its emphasis on societal and ethical implications of computing. Assignments in the course involved students in the basic use of computer applications (e.g., word processing, spreadsheets, and Hypercard) in the Macintosh environment.

CS 111 was designed to be a computer science major's overview of computer science. The course attempted to provide an introduction to the breadth of computer science with a treatment of programming as only a supporting topic. Prior programming experience was not considered a prerequisite for success in the course. Students enrolled in CS 111 met for three hours of lecture and one hour of recitation each week. The intent was to use lecture periods for discussing important concepts in computer science and recitation periods for presenting programming concepts. All assignments in the course involved the student in C++ programming. It was expected that the programming exposure in CS 111 would involve students with basic input and output, the use of control structures (including recursion), and issues of program design.

MA 201 and MA 202 comprised the two course sequence in discrete mathematics offered by the mathematics department. The catalog description indicated that topics covered during the two course sequence included elementary logic, mathematical induction, functions and sequences, finite and infinite sets, counting techniques, relations, graphs, trees, and semigroups.

The computer science department at the University resided within the College of Engineering. The College of Engineering referred to coursework in the freshman and sophomore years as the pre-professional program. Once certain coursework was completed (with at least a C grade in each course), students were eligible to apply for admission to the professional program. The professional program was the coursework completed during students' junior and senior years as they prepared for a professional career.

Researcher Contact with Students

E-mail offered an always open line of communication between me and the students who participated in the study. The UNIX utility, *finger*, displayed the time of a particular user's last sign on and also presented some personal information about that user. Through use of finger throughout the day, I gauged the students' use of the e-mail system and checked whether they had read their e-mail messages. Reports of system log ons throughout this chapter were obtained by my use of finger at various times during the day as the study progressed. E-mail was an important communication link between myself and the students. Finger provided a way to track how the students interacted with this resource.

In my first conversations with each student, I suggested that they try to establish some routine for writing their comments so that I would receive their e-mail journal comments by Monday of each week. The guideline of Monday comments was a guideline that Heather and Eddie kept in mind but the other students were much less regular with their written comments.

Fall Term

Two sections of the Fall term computer science course, CS 101, were available. One section was taught by the computer science faculty member, Winston, who designed and directed the course. The other section, the one in which all the students in this study were enrolled, was taught by a graduate teaching assistant, Aaron, who was working on his PhD in computer science. Before the start of Fall term classes, I contacted Aaron by e-mail, introduced myself and the research, and asked if he would be willing to participate. I explained that the purpose of the research was to gather information about freshman computer science majors' experiences and it was important to have the instructor as well as student perspective on coursework. Aaron agreed to participate and on the Wednesday before Fall term classes started, I talked with Aaron for about 45 minutes.

Aaron had been a teaching assistant (TA) for about five years. "My entire teaching background is at [the University]. . . . Basically they threw me into being a TA without any preparation whatsoever. They said just go do it." Aaron had taught or helped with other courses but Fall term was the second time he had taught CS 101. During the previous Summer term, Aaron had taught CS 101 for the first time. "I've done two or three terms of grading for it [CS 101], being a recitation TA, which gives me a fairly good background for helping the TAs this term and a decent background for teaching."

I asked Aaron how he felt about teaching CS 101 compared to other courses he had taught.

> I didn't have a good clear idea as to what the class was going to be about when I started it [this summer]. Winston wasn't around during the summer to help me much so I had to rely on notes especially. Other classes, for instance teaching Pascal, I'd taken Pascal before, I knew it quite well. I was able to talk about my own experiences from it. CS 101 was quite different. I'd never taken an introductory course in computers. . . . I was as new to it as the students were. . . . What I found most difficult was teaching the implications and social aspects of computer science. I tried to use antecdotal information whenever I could, especially from my own experiences, but I didn't feel like I had a really strong background in that. . . . But I think this time around I'll have a better idea of where the class is going and also where the information is coming from and why. I'll be

> working closer with Winston this term to make sure that the class fits closer to his concept of what we're going to be teaching.

I asked Aaron to talk about the type of student who enrolled in CS 101.

> I think it's rather an interesting introductory course. I somtimes think of it as computer appreciation, much like the art department offers an art appreciation course. . . . I'm sort of disappointed by how many people take this course expecting that it's going to be, "Ah, this is how I learn to use program X on the Macintosh." I would say about a third to half the course is like that but it's so much more. The course is also designed to teach students how computers are fitting into their lives. They're almost always shocked [and interested] especially when I deal about issues of privacy or . . . computer security. They have a certain hunger for this. . . . When we got to the social issues that was when they were most interested. I think that the class is possibly most important in that aspect.

I also asked Aaron to talk about what he thought it took for a student to be successful in CS 101.

> CS 101 is not a difficult class to take. If you do the homework, and you keep up on the reading, and you spend some time in the lab, you can easily get an A out of this class. It is not difficult. The problem is, a lot of people come in expecting this class to be easy. . . . The first one or two quizzes are very easy, as soon as they become hard I notice that people start faltering. . . . Also I've noticed that a lot of the people don't read the material. . . . The text is long. . . . Obviously you're going to have to keep up on that [the reading] every night because every night we manage to hit a new section. . . . This class is not supposed to be incredibly hard. It will take up time.

Aaron also spent some time reflecting on how his past educational experiences had affected his teaching. His undergraduate experience had taken place at a small college of about 1700 students.

> I graduated in a class of about 20 [computer science majors] which shows you that the department was actually rather small. And the professors there were able to do one-on-one talking with the students,

> something that's not available at the University. As an undergraduate . . . we were able to, whenever the door was open, walk into the department and ask the professors a few questions or even just to chat. I think that's affected my teaching style in that I become very personal with the students. If I go on to teach, I will probably teach in a small institution rather than a large one simply because I feel that one of my best talents is to be able to communicate and to teach people.
>
> Other things that have affected me from my educational experience — my major professor, I guess you could say, the person who looked over me [during my undergraduate years] had a particularly laid back approach to teaching. . . . [While teaching a course on compilers] he would write sections of [the compiler] the night before, come in, give an assignment sort of half hurriedly, and he'd walk through what he'd written the night before and try to tie that to the text as best as he could. If you were sharp and on the ball you could follow that. In fact his whole philosophy about teaching, he told us one time, he said, "Basically in computer science there are two types of students, those who have it, those who don't have it. Those who have it are the people who sit in the back of the class, they ignore the instructor, and they talk and they pass notes back and forth to one another, basically take naps from time to time too — those are the people who are going to get As. The other class of people, the people who don't have it, they're the ones who sit in the front of the class. They're the ones who take notes. They're the ones who diligently write down everything you say and spend many, many hours studying the text outside of class. They're the ones who are going to get Cs. With a lot of work, those who don't have it can raise their grade to a B. And those who do have it, if they don't do anything at all, are probably going to get Bs as well." . . . I've taken it with a grain of salt. . . .
>
> You'll probably see that sort of curve occur in CS 111 [the Winter term course]. In a general course like [CS] 101 I've discovered that it's pretty evenly distributed between As, Bs, and Cs. It might be an artifact of the grading, it might be the fact that it's more an issues sort of class rather than programming, but I honestly believe that there is that sort of double hump. I've seen it in other classes here as well. Oh, by the way, I was one of the people who sat in the back of the class, didn't take notes, talked to people back there, and of course always got As out of my courses.

Aaron also talked about how, in his experience, each change in the educational process was always something of a surprise.

> I think there is a mind set between high school, undergraduate education, graduate education. We don't do a lot towards preparing people for that.

> . . . If they [college freshmen making the transition from high school to college] haven't developed the proper study habits in high school they will flounder in their grades here.

Aaron went on to talk about how his teaching experience had also affected his teaching style. He had been quiet as a high school and undergraduate student and disliked speaking before a crowd or in public. When he was put into a TA postition he realized he had to speak and "tried all sort of tricks to try and avoid speaking to the class directly — look over their heads, read from my notes, try to keep it programmed." Aaron said that his fear was gone and he "sort of craved" speaking to a group of people. "Teaching is one of those experiences that you have to do in order to become proficient at it. There's no way you can become a good teacher overnight. You'll just simply learn. As you do it, it becomes easier."

Aaron spoke some about the conflict for him between the demands of teaching and the effort required to complete his thesis.

> Teaching takes a lot of time out of your regular day to day business and you cannot complete a thesis as quickly on a teaching assistantship as you can on a research assistantship. My desire is to graduate this year. . . . As a result I'm going to put secondary emphasis on teaching this year. . . . I won't be able to produce personal one-on-one teaching rapport that I have in previous terms or years. I'm going to try and keep this class down to a minimum of effort. That may produce a loss of quality in the class from the students' perceptions. It's unpleasant, it's difficult, but it's necessary. . . . I'm hoping that Winston will be a guiding effort in this class because I can't take the extra five percent that I've been giving in previous terms this term.

As the interview was nearly finished I gave Aaron the opportunity to comment on anything else he had been thinking about as he prepared to teach CS 101. He spoke about his concern for widespread cheating that he felt was rampant in the department. He wanted to make sure that he "came down hard" on anyone he caught cheating. Aaron had also noted from past course evaluations that he wanted to be more prompt to finish grading. Finally, Aaron had observed that students for whom English was not their first language had not done as well on the written portions of the class. He wanted to

emphasize that help was available. "The resources are there for you to make the paper perfect."

When the interview was completed, I thanked Aaron for his participation in the study. I expressed my appreciation for his willingness to write up weekly comments about the class from his perspective and for allowing me to make observations in his classroom. Aaron said he felt that the study was important and that he was glad to participate.

After one week of classes I had not received Aaron's comments on the week. I sent him e-mail reminders almost daily as I wanted to be sure that I received his perspective. After a week and a half of classes I received Aaron's comments. I had told Aaron to comment on goals, successes, frustrations, interactions with students, and anything he was thinking about related to the class. He had written a couple of paragraphs daily and I felt like I was getting excellent information from him. Once I knew Aaron's style for accumulating comments, I tried to be a little more patient and gentle in the reminders for Aaron to send his comments in the weeks that followed.

Many of Aaron's comments related to logistics of organizing the class, equipment, TAs, and coordination with Winston. Aaron's logistical comments have been largely ignored within this research. However, Aaron's comments related to the students' experiences in the class were of interest and are presented here.

The class met on Monday, Wednesday, and Friday in a large lecture hall. On days when most all the students attended, nearly every one of the 180 seats was filled. Another class met in the room immediately before CS 101 so students would gather in the hall before class to wait for entrance into the room. I attended class every day and made a habit of arriving 10 to 15 minutes before class to wait in the hall with the students. I frequently had conversations with Trent before class and occasionally talked to other students in the study as well. Only on rare occasions did I have conversations with other students in the class.

The first day of class was used to explain the syllabus and various class procedures. There was a lab quiz each week and typically Tuesday was the day in lab to prepare for the quiz and Thursday was quiz day, although quizzes could be taken early if students were prepared.

The syllabus described the course as focusing on the human side of computing. The syllabus also contained some discussion of the time demands of labs. Aaron spent no time discussing time demands in class in spite of his comments and concerns expressed in his interview related to the transition from high school to college and the importance of good study habits. The course schedule gave reading assignments and the schedule and topics for lab quizzes and exams. It became apparent that students were expected to follow the course schedule closely because throughout the term Aaron never reminded students of labs nor reading assignments nor stressed the importance of doing the reading.

On the first day of class, Aaron was not sure that his office phone number listed on the syllabus was correct and wanted to find better office hours. After two weeks of classes Aaron announced new evening office hours to be held early in the week in the lab. He hoped that the hours would give him a chance to meet with students and help them prepare for quizzes. After three and a half weeks of class, Aaron changed his office hours for the third time but kept evening hours.

At a couple of points in the first day's discussion Aaron made comments which might have left some students feeling uncomfortable. Aaron joked some about the difficulty of finding the building where the lab sessions were held. The building was known by a number of different names and Aaron offered little help in locating it. Students also needed to purchase "double-sided, double-density diskettes" for lab work. Aaron asked, "Do we assume that this group of students understands that?" He made no further explanation.

I had given Aaron an introduction of myself and the research to be read in class.

> Kathy Howell will be sitting in on this class as a part of research she is working on with the computer science department. Kathy's research will be attempting to describe the experiences of freshmen computer science majors here at the University. The computer science department is interested in using this information to make improvements in what they are doing to support their computer science majors. Kathy would be happy to talk to any of you and as the term goes by. If you have any comments that would contribute to this study, we encourage you to share them with her.

Aaron read the introduction much as an afterthought the first day as students had already begun to pack their bags. I felt that most students did not hear the introduction although one male student, Larry, came over to talk to me after class.

Larry told me he had thought about responding to my summer mailing about participation in the study but was so busy that he had not done so. He said he guessed that he was a computer expert and thought he should talk to Winston about being a TA for CS 101. I never talked to Larry again but noted with interest as Larry wore his cellular phone to class and sat in the front row each day. Larry nearly always spoke with Aaron before or after class.

Enrollment in the course was about evenly divided between males and females. Aaron had little interaction with the class but for the first week only male students spoke up to answer or ask the handful of questions that were asked.

The first week's class sessions covered the history of computing and people in computing. Many of the examples were related to the military (gun trajectories, radar systems, navigation tables and how errors led to deaths) and virtually all of the persons involved were male. Throughout the term Aaron used male pronouns nearly exclusively in his lectures when he referred to persons using computers in some way.

During the first week, and in the weeks that followed, technical difficulties occurred from time to time. The first time Aaron went to show a video he could not figure out how to get the sound to work so class was dismissed 10 minutes early. Aaron felt these problems were inevitable but the students always seemed to get a chuckle out of the technical problems in a class about technology.

Following one week of class Aaron felt that technical problems within the lecture presentation were unavoidable. After two weeks, however, Aaron observed that the technical problems that continued to plague him could be prevented if he put extra time into preparations and did an equipment check before the actual class. The problem was that he did not feel he had the extra time to give as he tried to focus more attention on his thesis. As the term progressed, it also seemed that for one reason or another Aaron found himself required to give extra time to fill in for a TA's section or for Winston's class.

Aaron noted in his comments that he thought the TAs were thrown into the class too suddenly. "The TAs may not have been prepared enough for the first recitation. Strangely, that's how it was for my first time, too." Because of his concern for the TAs' preparation, Aaron eavesdropped on his section's recitations and felt that the two male TAs both did a good job "for their first time." I sat in on Trent and Eddie's recitation and at two different points the TA was asked to speak up, each time by a woman student. The TA for Trent and Eddie's recitation was also the TA for Samantha's recitation. As the term progressed, Eddie, Trent, and Samantha's TA developed the pattern of reading a book while monitoring his lab sessions. Frequently students were required to make repeated attempts to get the TA's attention and wrest him away from his book.

Starting with the second week of class, Aaron brought a Macintosh computer with him to class each day. The fact that he had to set up the computer equipment every day before class, cut into his interaction with students before class. The computer was used to demonstrate software or to present the lecture notes. The projection of the computer screen was small and dark which made reading the screen difficult from most parts of the room. Winston had designed the first lecture notes to be presented with the computer. Before the first computer assisted lecture began, Aaron warned the class that the lecture was going to go fast. Aaron said that he thought the lecture files would be made available one week later but I was never aware that the lecture files were made available. The material was presented quickly and few students took notes. At one point in the first lecture of this style, a woman interrupted Aaron to tell him to slow down. In the class period which followed the first computer-aided lecture, Aaron admitted that the presentation had not gone well.

Aaron discussed the computer presentation problems in his journal comments. As the term went on Aaron started putting together the computer presentation of the lecture and attended to some of the problems. After a couple of weeks he developed a style and pace that made the system work though the screen projection remained small and dark.

In the second week I continued to note in my observations that at least 90 percent of student involvement in class, with questions or volunteered responses to Aaron's questions, was by male students. Often the questions by males went beyond the material

presented or attempted to show in some way that they had mastered the material. As Aaron answered questions at the front of the room after class, however, more females than males usually waited to talk to him.

By the third week people were leaving the lectures early when Aaron was lecturing and using the computer to present notes which were almost exclusively contained in the textbook. In the fourth week I noted that there was more noise and talking among the students during the lecture. Attendance had started to dwindle and I observed that more and more of the students in class were otherwise occupied during the lecture or somehow presented the image that their time would be better spent not sitting in class for CS 101. Of the students leaving early or looking disinterested in class, about two-thirds of the students were male, one-third female.

On two different class days during the third week, a woman student asked about the problems with Microsoft Works "crashing" in the lab. Students were frustrated by the software problems and the problems were particularly distressing when they occurred in the middle of completing a quiz. The software problems persisted into the fourth week. Aaron sympathized with the students and invested some extra effort with a lab consultant to resolve the problem.

By the third week, comments from student participants in the study with regard to the discrete mathematics course had led me to believe that the real challenge in the term for the students was MA 201, not CS 101. Eddie had asked what I knew of the Math Learning Center on campus and I thought it was important that I learn more about the course. From persons in the computer science department I learned that MA 201 had a reputation as a difficult course. I talked to some persons in the mathematics department and was directed to talk to a female graduate student, Beth, who had been a teaching assistant for the course a number of times though she was not currently a TA for MA 201.

Beth had a special concern for MA 201 and was happy to talk to me about it. Beth first explained that the Math Learning Center was staffed by graduate students in mathematics many of whom were unable to provide assistance with MA 201 because they lacked the necessary background and experience. Beth had been asked by one of the term's MA 201 professors to prepare a list of days and times when persons who were able

to provide assistance to students in MA 201 were available in the Math Learning Center. Beth gave me a copy of the Math Learning Center TA list when she completed it at the start of the fifth week.

Computer science majors at the University were expected to complete the two course sequence in discrete mathematics followed by a three course sequence in calculus. Beth explained that the discrete math sequence emphasized proofs while proofs were not a part of the calculus sequence. Beth felt that the students who did well in discrete math were either math majors or junior and senior computer science majors who had been exposed to the material in prior computer science courses. The general guideline, however, was that students who were ready to enter the calculus sequence were considered ready for the discrete mathematics sequence. Universally, throughout the first term, comments from the student participants in the study indicated that they struggled with MA 201 and felt ill-prepared to master the course content.

Friday of the third week, Aaron distributed descriptions of "bonus projects" that students could complete to earn extra points in the course. Aaron started discussion of the projects and handed out the descriptions before it was time for class to start. He also commented on how few students were in class. (Friday attendance was typically marked by more absences than other class sessions.) Aaron decided to give a "bonus quiz" for the day to give everybody in attendance a few bonus points.

The first midterm exam in CS 101 was given on Friday of the fourth week. As I read over the exam it seemed fairly easy and the vast majority of students were finished in 40 minutes. Aaron's journal comments left a gap of about a week and I never heard his comments on the first exam. Aaron's journal comments did discuss problems with the exam scoring for the midterm exam. Two mistakes were made on the exam key and then other mistakes were made in the attempt to correct the first mistakes. After being reprocessed two times, two questions were thrown out on the exam because of grading problems.

Early in the fifth week an announcement about advising appeared in the computer science department's electronic newsgroup available on the Internet. The announcement informed students that the following week was undergraduate advising week for the next

term's enrollment. I questioned whether most freshmen students knew about or read the newsgroup and assumed that the information would be communicated by additional channels. No announcement of the advising information was made in class. After a week I sent a copy of the announcement to all the students in the study. I asked the students to let me know if they were already aware of this information through other channels. Through their freshman orientation class students were aware of the need to pre-enroll for the following term but they were not aware of the specific computer science department procedures for advising and enrollment. The copy of the announcement I sent to the students was their first notification of the need to sign up for an advising appointment with their advisor. Winter term the advising announcement process followed a similar pattern. An announcement appeared in the departmental electronic newsgroup but no announcement was made in class. Winter term I did not send the study participant students a copy of the newsgroup announcement.

In the fifth week of CS 101, I noticed that more women were asking questions. I had noted a couple of times prior to the fifth week that Aaron did a good job of answering questions in such a way as to not make the student feel like any question was a "dumb question." Also in the fifth week there were more times when students raised their hands with questions and Aaron failed to recognize them. If students did not call out their questions, Aaron tended only to recognize students in the first three or four rows.

I continued to notice Aaron's choice of examples. He had said in his interview that he tried to use antecdotes from his own experience and often it was obvious that many students could not relate to the examples used. One day Aaron related the story of a form letter mixup where the name used had been "Rich Bastard." Some students were obviously uncomfortable with the choice of names. Frequently Aaron's examples involved concepts that students did not understand. As a result, students were unable to understand the example or recognize its importance. As Aaron talked about a weather simulation, two women near me commented to each other that they did not understand "thrust, drag, or Brownian motion."

Early in the fifth week an intruder broke operating system security on all the UNIX machines in the computer science department network. All the computer science

department UNIX machines, including the machine I usually used for my e-mail access, were left non-functional. Aaron spent some time talking about the attack before class one day and, as was the usual pattern, exclusively referred to the attacker/hacker using male pronouns.

Aaron lectured on computer crime on Monday of the sixth week. Aaron had indicated in his interview that the computer crime lecture was one of his favorite lectures. I noted in my observations that the students talked less among themselves during the lecture and seemed to listen more than usual. "They [the students] stayed almost the entire hour — that shows that this is one of the more interesting lectures this term. It is one of my more anecdotal lectures. I put a lot of interesting information in."

One of Aaron's examples in the computer crime lecture was about how he had managed, quite by accident, to gain knowledge of the cash register security code at a local store by watching a novice cashier make numerous failed attempts and solict help from the manager. I thought it was unfortunate that in this example the computer user was female where in the vast majority of Aaron's examples the computer user was male.

Also as a part of the computer crime lecture, Aaron made some comments about the flaws in e-mail security. A couple of days later in a lecture on telecommunications, Aaron again described e-mail as neither secure nor private. I wondered if the students sending e-mail to me as a part of this study were concerned by Aaron's comments. About a week later Eddie did ask me to show him how to encrypt his mail but Eddie's security concern was that he did not want his dad (who sometimes accessed his account) to read mail sent by Eddie's girlfriend.

Frequently Aaron ran out of time before he had completely presented the day's lecture material. Aaron commented that, "One of my personal devils is getting through the lecture materials. I can never seem to do it." A few days after making this comment Aaron said, "I'm not going to worry too much about how the class is supposed to learn the information that I have not covered in class. I have given them ample warning that the first source of material is the textbook."

I had noticed that Aaron's comments contained nothing about his interactions with students. I asked Aaron to try and include student interaction information and in the sixth

week Aaron started to make some comments about his contacts with students in the class. He mentioned that he knew a couple of students, including Larry, through the railroad club but said that "sadly, beyond a short list, I really don't know the rest very well."

Friday of the sixth week, two weeks after the first midterm exam was given, Aaron realized that grades needed to be posted but grades were just returned from the final processing of the first midterm. The need to post grades was discussed in the weekly TA meeting with Winston. On Monday of the seventh week Aaron noted that students were asking about grades. Aaron checked but the TAs for only about one-third of the students were current with entering grades. A week later Aaron made a comment in class about his displeasure with the TAs' tardiness in posting grades and returning projects. Students voiced their concern as well and Aaron listened. A couple of days later Aaron discovered that grades were posted in a different location than he had told students but a couple of the TAs were not current.

The second midterm exam was on Friday of the seventh week. In the class session before the exam, Aaron fielded questions about the exam. Aaron told students there would be no multiple choice questions on the second exam and listened to the students' comments about the prior exam. I wondered about the decision to construct an exam consisting entirely of short answer questions when Aaron had expressed a concern in his interview that non-English speakers had not done as well on written portions of the course when he taught the course in the Summer term.

As I sat in on the second midterm exam, I noted that the exam did not seem as easy as the first exam. A couple of questions covered material from the textbook reading not covered in class. In general students took about five minutes longer to complete the second exam than the first exam. Students were required to show their student ID as they turned in their exam as proof that their name was the name of the person who took the exam. Aaron and one of the TAs proctored the exam and only a few students that they knew were not required to show their ID.

Aaron noted in his journal comments that he had asked a few people about the exam as they were leaving. "They felt consistently that it was easier to answer than the first one. We'll see." In the class period following the second exam, some discussion was

held as to whether the final should be all short answer or multiple choice. A vocal male toward the front of the room lobbied for multiple choice. When Aaron said, "Okay, the final will be multiple choice," some women complained. Again, Aaron did a good job of listening and fielding student comments.

After class Aaron talked to the women who wanted a short answer exam. Aaron listened to what they had to say and noted their comments in his journal.

> They feel that short answer questions are more general and more in the "spirit of the text" because they ask for a general comprehension of the field of computer science and not just fact memorization. I'll keep this in mind. After all, short answer tests are easier to write, though not easier to grade. They also are shorter and allow partial credit on wrong answers.

In the end, most of the questions on the the final exam were multiple choice and most people finished the exam in an hour.

Following another class discussion in the eighth week about grades not being posted, Aaron initiated a conversation after class with the student who had complained the loudest. Aaron noted in his journal that she was "surprised and a bit embarrassed" that he wanted to talk to her.

> I told her that I appreciate more the students who get actively involved in the class and that there should be more students like her. I do mean that. When students ask questions and get involved, I get into full swing and get the information across better. Her reply surprised me. She said that all she wanted was to find out what her grade was; after all, this was over halfway through the term and she still didn't get much info on her status. I hate to see that this is what it takes to get a student to speak out.

The following class session Aaron extended the due date for the term project from the day before Thanksgiving to the day after Thanksgiving because students were delayed on the project by the slow return of a prerequisite assignment.

With three weeks left in the term (two weeks of classes and finals week), I received Aaron's final comments. He commented at the time about the conflict he was feeling between demands of thesis work and demands of teaching.

> I feel that my involvement in the class has suffered somewhat because I have been emphasizing my thesis more. . . . At one end of the spectrum I want to teach and feel I get great experience from it. At the other end, teaching is merely a distraction and a means to support myself in getting the real goal — a thesis. I often fluctuate between these opinions as time becomes more, then less available.

I sent numerous e-mail reminders and spoke to Aaron in person a couple of times in the six weeks that followed his final comments. He was never able to make the time, however, to send his journal comments on the last weeks of class or to sit down for a final interview after the class concluded.

In the eighth week I continued to have questions about the portrayal of male and female roles not only in Aaron's examples but also in the videos shown in class. In an Association for Computing Machinery (ACM) video all the "experts" were men and the only women in the video were in the footage of a data entry sweatshop where all the employees were women. In the same week a video on artificial intelligence portrayed: five male experts, one male researcher, four male computer users, one female programmer, two male programmers, one female chef, and one female weaver. Aaron's artifical intelligence examples in the ninth week were a man shaving, an army research team using neural nets to recognize tanks, and a male car repair expert's use of an expert system to deal with car repair diagnosis.

Two class sessions in the eighth week were spent on a survey of the field of computer science and its history. The ACM defined computer science as consisting of computer theory, algorithms, data structures, programming concepts and languages, and computer elements and architecture. Aaron presented his own alternative definition which defined computer science as interdisciplinary — electrical engineering, mathematics, business, any field using computing applications.

In the ninth week of class, the day before Thanksgiving, Aaron presented a demonstration of Mosaic. Mosaic and its associated applications present a multimedia front-end for browsing the Internet and World Wide Web. Two weeks earlier Aaron had written comments in his journal about his discovery of the Mosaic program. "What a great program! . . . This is the perfect program for the class. . . . It is perfect and would

be the ideal thing to put before the class — open their eyes, so to speak. Just getting the 15-minute-old weather map will impress them." Aaron's enthusiasm for the program and the information available on the Internet was clearly evident in his presentation in spite of some technical difficulties. The person who was to arrange for the demonstration was late and 10 minutes of class had passed before the equipment was ready. Then in the course of the demonstration certain points of demonstration failed to work because of the type of equipment used. Also, response time on the network was slow and students became restless with the long wait times and pauses.

Aaron's enthusiasm and interest in computers was clearly evident on many occasions. As the term progressed it also became clear that for some students Aaron's enthusiasm was somewhat annoying or embarrassing. Student annoyance or embarrassment was clearly evident during the Mosaic demonstration and also in response to a comment Aaron made in the following class session. Aaron's comment came as he made the point that computer equipment breaks down and he said that his computer monitor was currently not working correctly. He stated that he thought the problem was "probably a flyback controller." This extra bit of detail about the possible problem seemed like too much and in response some students rolled their eyes or snickered.

In the final week of classes students were quite clear in their messages about how they felt about class. Attendance was the worst ever with at least one-third of the students not in attendance. Aaron's lectures were accompanied throughout by much talk among the students. By the time Aaron finished his lecture each day at least one-third of that day's students had left early.

On the final day of class it seemed that most people were in class only to gain some insight about the final exam. Aaron lectured until the last five minutes in the class period. He seemed to be enthused about the material and the fact that students were not leaving early. They were waiting to hear about the final. Aaron talked about the final and answered questions until the period ended. When the bell rang Aaron asked the students to come down front to pick up a course evaluation form to complete before they left. Fewer than 20 students completed evaluations. Aaron offered students another chance to

complete course evaluations on the day of the final exam but I did not observe that anyone completed one that day.

Winter Term

In the week before Winter term classes began, I interviewed Rick, the instructor for CS 111. As the head undergraduate advisor, Rick was the one who had given me access to names of students to contact for possible study participation. During the interview Rick commented that it might be fairly easy for him to figure out who the student participants were. I sensed from him, however, that he only wanted to act in ways that were supportive of the study.

From our preliminary discussions before the start of the study, Rick was familiar with the goals and premises of the study. He repeatedly assured me of his concern for supporting more women in computer science and his concern for improving the general undergraduate experience in the computer science department. Rick's support for the study was manifested in his openness to talk and share his classroom and course with me. Rick also repeatedly asked for my input throughout the Winter term and was always interested in hearing anything I might be able to tell him about what I was learning. He was frustrated that I was not able to tell him what I was finding while the study was still in progress but he understood and remained supportive.

In the interview before the start of Winter term I asked Rick to talk about his teaching philosophy and how it had developed.

> I guess the most important thing in terms of teaching, particularly computer science but maybe in all areas, is that the most important thing for the students is to learn by doing. And that's a very difficult sort of thing to do because a lot of students don't want to do that. They want to be spoon fed and so I have a difficult time with those students because I lose those and maybe those fall into the category of the ones who hate me. So that's probably the most important thing in the classes and what I try to do is to prepare them as much so they know how to solve the next problem as to give them the answer to all of the problems. We do examples. I try always to give them similar kinds of things but I do expect them to make the jump

> but I do expect them to do some work on their own. I give them a similar problem, the solution to a similar problem, and we go over that in class always for their programming assignments. But I always want them to make the next step. I do that a lot on my exams, too, which is difficult for students, a lot of students.

Rick talked about how he had come to the field of computer science after he had earned his PhD in biology. He was forced to learn much about computing in order to support his research demands in population biology. "I came to computing from a user instead of a theoretician and so that puts me in a little bit different perspective than many of the faculty members in the department here who began computing from the computer scientist's point of view."

Rick had taught biology for 20 years before teaching computer science. I asked him to compare his teaching in the two fields. "There's a lot more factual stuff in biology so that while I still try the same approach [learning through work on a problem] in biology it was much more difficult than in computer science. . . . There's a lot more problem solving kinds of things in computer science than there is in biology."

I asked Rick to describe his goals and the department's goals for CS 111.

> We're doing something that, and eventually we may give it up here too [laughter], we're doing something that everyone knows is right and everyone knows is important in computer science but that never works, that is to teach, to get a survey of computer science at the beginning level so the students get exposed to what computer science is. Students think that computer science is programming and it is not. They all come in with that although now we have a lot of people also coming in thinking that computer science is using a database. That's a problem that started about five years ago because there are a lot more people using computers now than there used to be as computers have reached out into every area of life.

Rick talked some about the struggle to dispel the students' idea that computer science is programming.

> That's usually what their first exposure is [programming] and so that's what they think it [computer science] is. And for those with any

> experience, that's what they love to do. It's hard to distract their attention from that and point out that there are other things that are really important. To make progress you really need to understand some basic principles and so on. . . . So we want them to see what computer science is and we do do some programming and I try to use the programming to work on examples of what we're talking about so that we do do recursion and so on but we don't even get to arrays in the first course. We do control structures and so on but we want them to see how important design is and how important documentation is as a part of programming which is also something that people resist. . . .
>
> We talk about computability, and we talk a little bit about history, and we talk a little bit about things like Turing machines and so on so that they can see what computer scientists do in the breadth of it and we try to use the programming part to solve those particular problems and I may even do less programming this time. . . . The students who love programming then are sort of turned off by that sort of stuff [discussion of computer science topics without programming] and they may not see that it's important until later.

On the second day of class Rick defined computer science as the "science of algorithms, their design, execution, communication, and representation." To students with little knowledge of computer science, Rick's definition might have sounded like "computer science is programming."

Winter term was the third time Rick had taught CS 111 and he talked about the difficulty of teaching a course like CS 111.

> Now there's this cycle, almost every department has this, where they try this method and then they give it up because it's unpopular. They go back to straight programming and let them get the other stuff later on. Then they see that that doesn't work either and so they cycle back and do a 111 for awhile and the students hate it and the faculty who teach it get low evaluations. I get much lower evaluations in 111 than I do in all my other courses. And I haven't been able to change that. I fix the things that they don't like and I know I did much better on that and they don't complain about that the next time but they still hate the course. . . .
>
> What caught me off guard last term was it turned out that there were quite a few [students] who hadn't had any programming experience and so it's a difficult course to teach because on the other hand there's a third of the class who are hackers and have been programming for five years and are bored to death with the programming assignments. . . . This particular course probably has the greatest diversity of backgrounds in a particular

> subject matter for any course that I've ever taught before. . . . It's tough so I'm going to be walking that tightrope again I know.

Rick wanted to be sure he had a good idea of students' programming backgrounds when he taught the course Winter term. He had asked for a show of hands in previous terms but he thought maybe students were more honest on an anonymous paper survey. He expected to use information on student experience as a help to him as the course developed through the term.

Rick talked about the last time he had taught the course when he was unaware of the large amounts of time and frustration that students invested in completion of the assignments. He only knew that when the assignments were graded, one group finished the assignments correctly and another group apparently did little toward completion of the assignments. He did not have a feel for what students were experiencing to complete the assignments. "[This term] I'm going to move my office hour [maybe three hours per week] for this class into the lab like the TAs do so I'll get a better feel for that."

I asked Rick to talk about the keys to student success in the course. "The keys to success are to keep up with the exercises and the assignments and the other one is to ask questions in class and I try to emphasize that and come for help if you [need help]." Rick talked about the importance of student questions as a gauge for him to judge student understanding. If students did not ask questions he had no information to guide his coverage of the material. Rick said he asked for questions at the start of every class and encouraged students to write questions on paper if they were shy about verbalizing their question. Rick also pointed out that e-mail was another way for students to reach him with questions, although some students may not choose this route since it is not anonymous.

I gave Rick the opportunity to discuss any changes he was considering for the course. He talked about his desire to do more exercises that highlighted the importance of discrete mathematics. He felt that the way the mathematics department taught discrete math was proof intensive with few examples or applications to computer science. Rick felt that the persons who taught the discrete mathematics course did not understand the computer science applications so they did what they were comfortable with, proofs.

"They do proofs all the time rather than applications and discrete math is very important in computer science." Rick wanted to give students the opportunity to see the importance of discrete mathematics.

Rick also commented on his feeling that there were not many good textbooks for a course like CS 111. The book chosen for the term was *Computer Science: An Overview (Fourth Edition)* by Brookshear. The Brookshear book was the only text Rick had designated for the course, consequently no text contained the course material on C++ programming.

> The problem with Brookshear is that the programming part is not integrated at all and it's in the wrong language. . . . I may want to go back and take a look at a book again. I have to see what this class is like. There is a very good book, one very good book I think, that we could have used in this course but all the rest of the faculty thought it was too elementary. The problem is that those were all people who taught upper [division], graduate courses and so it was poo-pooed so badly I didn't even dare consider it. If I get another term of experience like I've had, the students may convince me that that's the level we really ought to be teaching. . . . In a sense that really is the level that I teach the course.

After the interview I talked to Rick about my expectations for his journal, its content and frequency. He made some notes and perhaps had good intentions but I never received any written comments from Rick. Instead he talked to me before almost every class session. (I usually sat near the back of the classroom.) Rick invited me to sit in on his weekly meetings with the TAs for the course and I usually talked to Rick before and after the TA meetings. In the course of our frequent conversations, I gathered better information than I expected from a weekly written journal.

The second interview with each of the student participants in the study was conducted either on the Sunday before Winter term classes started on Monday or at some point early in the first week of classes. I commented in my journal following the interviews that the interviews went well. Everyone was more relaxed than in the first interview and all the students felt free to talk. Even though my contact with the students

throughout Fall term had included little if any extended face-to-face conversation, a level of trust had developed which carried over into the interviews.

CS 111 met in the same large lecture hall where CS 101 met Fall term. On the first day of class I estimated that 180 students were in attendance as there appeared to be no empty seats. Nineteen of the 180 students were female. The first day was spent in discussion of the syllabus and the dishonesty policy. Rick spent roughly equal time on each of these two documents. Rick said that the dishonesty policy should not get in the way of learning but at the time I questioned to myself whether the amount of class discussion time spent on the dishonesty policy might tend to discourage students from helping each other.

After discussion of the syllabus, Rick asked if there were any questions but he did not look up to see two persons who had their hands raised. This scenario of asking questions and not looking at the students was often repeated throughout the term. Sometimes students raised their hand for awhile and then when they were not recognized they called out their question. Sometimes the question was never asked. Rick always started class by asking if there were any questions. If there was a question, Rick frequently answered one question and then did not look or give time for other questions. Of course, some days Rick did a better job of handling questions.

Rick wanted me to attend his weekly meetings with the TAs for the course. These TA meetings usually happened on Wednesday afternoon and recitations for the course were on Thursday. This schedule gave the TAs little time with the material they were supposed to cover the next day but it did give Rick time to determine where he was in presentation of the course content. Rick prepared all the materials for the recitations. The TAs presented the material and sometimes filled in with their own additional examples.

The course had three TAs, John, Kyra, and Shawnti. All of the TAs were graduate students in the computer science department. John, a male, native English speaker, led the recitation that Heather and Samantha attended. Kyra, a female from India, spoke good English but had a heavy accent. Trent was in Kyra's recitation section. The third TA, Shawnti, another female from India, also spoke good English but spoke with an accent that was not as heavy as Kyra's. Devon's recitation section was led by Shawnti.

Most of the time at the first TA meeting was spent with discussion of recitation logistics, office hours, and the computer to be used in the first recitations. Rick introduced me to the TAs but it was clear that he had already told them about the study. At the meeting he described the study as a look at the first year of the computer science curriculum. Prior to this meeting, John and I had met each other as fellow graduate students and I knew John was interested in teaching. My impression after the first meeting was that John was comfortable with my presence and Kyra and Shawnti were more intimidated by my "looking over their shoulder." In the second week's TA meeting Kyra made a comment to me that it did make her nervous to have me sitting in the back of her class. I assured her that I was only there to observe in a positive sense, not to critique.

Rick spoke to me after the first TA meeting and encouraged me to speak up in the meetings and to give input and insight. I explained to him that while that might be helpful, I was there to collect data and not impact the natural course of events. Rick was disappointed but understood.

I attended Kyra's and John's recitations during the first week. John sat in on Kyra's recitation because his recitation was during the following hour. He was able to observe the software failure that precluded presentation of the demonstration in Kyra's recitation so the software failure did not come as a surprise to him when it also happened in his recitation. The TAs were forced to discuss how to edit, compile, and execute a program without being able to show the class the actual computer screens and operations.

In the first recitation Kyra's accent did not seem difficult to understand but a student did ask her to speak louder. It was clear that Kyra had not done much teaching. She seemed nervous and unsure of herself. Kyra became defensive when students asked questions and she failed to hear a couple of questions that students asked. One of the largest outcries from the students was when Kyra said, "We'll be using C++. I assume you all know C." Many students called out, "No," and John also confirmed to Kyra that one of the goals of the course was to teach some C++. As students were leaving on the first day, a male student joked to another male student, "She's the best teacher I've had all day."

In John's recitation, I noted that in his teaching he exhibited more concern for student understanding than Kyra did in her teaching. John helped students follow his

discussion in the handouts. He focused less on the details of the material to be presented and talked more in terms of what students needed to know to complete the assignment and what potential problems they might encounter.

Rick spoke to me before class on Friday of the first week. John had written him a report about the recitations. Rick told me that he wished he had the time, rooms, and staff to enable him to reduce the numbers of students, currently about 60, in each recitation. Rick joked that maybe he would "give an exam to weed out some of the students."

John attended class regularly and on Monday of the second week he wrote an announcement on the chalkboard. Rick reinforced this announcement at the start of class. The announcement reminded students that the first assignment was due on Thursday and suggested that since the number of students greatly exceeded the number of computers in the lab, they should not wait until Wednesday night to start on the assignment. I saw John after class and John said he had not seen any students in the lab during his office hours so he was concerned that they were not working on the assignment yet.

Different compiler software had been used the last time Rick taught the course. It seemed to be a surprise to Rick that this term's software was only available on campus in the computer science department's laboratory. Because the compiler was only available in the computer science department laboratory, sometime each week 180 students had to complete their assignments on 35 computers.

In the second Monday's lecture, Rick made a number of little mistakes and omissions throughout the lecture (which students pointed out to him). By the end of class I felt the class was beginning to get impatient with Rick's errors. I also noted that with about 10 minutes left in class the students faded in their ability to take in any more new information. Rick had covered a lot of material in one 50 minute lecture.

In the second week's TA meeting, the TAs expressed some discomfort in giving assignments to write programs in C++ when the students "didn't know C++ yet." Rick explained that the students would learn C++ as a part of doing the assignments. In general the C++ material was covered in recitation and class lectures concerned general concepts in computer science. As the term progressed, however, Rick recognized the need to spend more time on the C++ material so that students were able to complete assignments.

By the end of the term Rick spent considerable class time in discussion of C++ programming.

I attended John's recitation in the second week. Students were leaving Kyra's recitation as I arrived. I overheard two men and a woman from Kyra's recitation asking each other, "What are John's office hours?" They had just asked Kyra for clarification on the assignment and were not satisfied with the help they received. As John finished his recitation I felt that he had clearly and thoroughly explained the material and linked it well to the assignment.

After two weeks of CS 111 lectures, no women had spoken up in class to ask questions. The one older woman student (perhaps in her 50s) had spoken up to correct a mistake of Rick's but otherwise only male students had spoken in class. The women did ask questions in Kyra's recitation but no women had asked questions yet in John's section. I also noted, as I had in CS 101, that many times the men asked questions that went beyond the material presented and their questions served only to show that they had some knowledge of the material beyond what was presented in class.

Perhaps because of his role as head undergraduate advisor Rick occasionally did "informal advising" as a part of class. During the second week he passed out copies of the weekly computer science department newsletter. He pointed out that it contained important dates and deadlines and opportunities for which to apply.

Monday of the third week was a holiday but on Wednesday I asked Rick to introduce me to the class. He explained that my research was looking at the first year of the computer science curriculum and I welcomed any student comments anytime.

Because Rick's regular visits with me before class reminded the students that I was in contact with the instructor as well as the student participants in the study, I sent a note in the third week to all the students in the study. The note assured the students that unless they told me otherwise, I would treat all their comments as confidential.

The assignment due on the third Thursday frustrated a number of students. Rick talked to me before class on the third Wednesday. He jokingly told me that he had let the students struggle long enough and now he was going to go over an example in class that closely paralleled the week's programming assignment. He wanted the students to see all

the phases of a solution — specification, design, and coding. I asked if questions had prompted his lecture for the day. He said he had heard no student complaints but that did not mean there were not any. The example Rick covered in class did quite closely parallel the actual assignment. The older female student caught me after class to say that Rick could have saved people a lot of frustration if he had done that day's lecture a week earlier.

I watched with interest as three male students toward the front of the class listened to Rick discuss the programming example on the third Wednesday. One of the students had a portable Macintosh computer with him which he used to take notes during class every day. These students exchanged glances of shock at each point where Rick went into specific detail about the tricks of doing the assignment.

During the third week's TA meeting the TAs made some adjustments to their office hours and everybody wrote their new hours on a sheet in the computer science laboratory. Apparently the adjustment on paper in the laboratory was the only notification of the changed hours (unless mentioned in recitation) as a week later no announcement had been made in class.

Discussion at the TA meeting on the third Wednesday started with comments of how busy the TAs had been that day with questions during their office hours. Rick had been busy also and his materials for the recitation presentation were not prepared in as specific detail as was Rick's usual pattern. To make a point about the importance of good specifications, the TAs were to hand out a poorly written description of the third assignment. Rick wanted students to read and question what they were to do. Rick planned to discuss their experience and hand out the real assignment in class the next day. When Rick did discuss the "fake assignment" and the real assignment number three in class, most students were relieved and laughed. Some students clearly did not appreciate the lesson.

I went to Shawnti's recitation in the third week but Rick was covering for her that day. Male students asked all the questions and half of those questions were of the type where the students were showing that they had knowledge beyond the presented material.

There were many questions in class on the third Friday, including a question about the meaning of the description for assignment three distributed in recitation. There were 13 questions asked and the only one asked by a female was asked by the older female student. Again, two or three of the questions by the male students showed knowledge or experience outside the course. The first question asked by a female, other than the older female student, was on Monday of the fourth week. In the course of the entire term female students, other than the older student, spoke out in class only three times.

Class on Friday of the third week included some discussion about the shortage of textbooks in the campus bookstore. The first exam was one week away and about 20 students did not have a copy of the text. Rick said he would make 10 photo copies immediately available on reserve in the library. The bookstore copies arrived by the following Wednesday.

Rick made study questions and a prior term's exam available a week before the first exam. Rick also checked with the class and scheduled a generally suitable time for a review session. Rick conducted the review session on Wednesday night before the exam on Friday of the fourth week. I was unable to attend the review session but Rick stated in class on Wednesday that the review session would last from seven o'clock in the evening until no more people or questions remained. Rick said that he was comfortable with people coming and going during the session and suggested that a student could come late, ask one question and leave.

Most of the fourth week's TA meeting was spent in discussion of student complaints. Rick had received e-mail comments from some students stating that the TAs were not available during their posted office hours. The TAs indicated that they were always there, just sometimes maybe not at the TA desk but rather working at a terminal somewhere else in the lab. One student had written a letter with multiple complaints regarding assignment number two — there were inadequate numbers of computers in the lab, lab hours needed to be extended to accomodate the number of students and the fact that CS 101 utilized the lab for recitations, class materials were inadequate and contained errors, the second assignment was too much of a jump in difficulty from the first

assignment, and the lecture that contained detailed help for completing assignment two should have occurred at the time the assignment was given.

A large amount of material was covered in recitation the fourth week. Usually handouts accompanied the overhead transparencies but none were available the fourth week. I attended Shawnti's recitation and she covered all the control structures (IF, IF-ELSE, FOR, and WHILE) in 40 minutes. Students who had prior programming experience probably understood all the syntax information they needed if they paid close attention to all that was said. Students with no programming experience needed to understand the concepts of four different control structures and the syntax. All students were expected to apply these concepts in completion of the fourth programming assignment which expanded on the third assignment.

Rick told the class the fourth Wednesday that he targeted exams for the first person to finish in 20 minutes and for one-third of the class to finish in 30 minutes. The first exam was right on this target and three-fourths of the students had finished the exam in 45 minutes. The exam included the expected material and type of questions. There was no C++ programming on the exam.

The fifth Wednesday Rick lectured on C++ functions. Rick indicated that C++ material was really recitation material but recitations were spent that week reviewing the exam so that students had a chance to learn from the exam. I attended Kyra's and John's recitations the fifth week. In both recitations exams were returned in a manner that exposed students' names and exam results to all other students as they retrieved their own exam.

During the fifth week, the policy changed in the computer science department's computer laboratory so the computers were not available for CS 111 students to use between 8:30 am and 1:30 pm Monday through Thursday. The excluded hours were when CS 101 recitations met and CS 111 students had been able to use machines if extra machines were available. The distraction of other students working had prompted the change in policy. Within a week, however, the lab hours had been expanded to 24 hours a day, rather than only until midnight.

On the fifth Friday John's wife was involved in a serious accident. Rick announced in class that he would cover for John but probably would not cover his office hours. Rick distributed the fifth assignment on this Friday. The lecture was again C++ specific and covered functions, scope, a review of control structures, and introduced the SWITCH control structure. All of these topics were essential to completion of assignment number five (another extension of assignment three and four).

In the sixth week, after the first exam had been graded and returned, I noticed that attendance in class and recitations had reduced considerably. I missed the sixth week TA meeting when it was decided to give students an extra week to complete assignment five because they were having many difficulties. I attended Kyra's recitation and she forgot to make this announcement. The extended deadline was also not announced in class on Friday. The recitation topic of the sixth week was a review of functions in an attempt to address some of the student problems. Kyra did a good job of speaking to questions that she had heard many times during her office hours at the lab.

I also attended Shawnti's recitation in the sixth week and I clarified with her before class that the due date had been extended on the assignment. She had been confused but after talking to me understood that students had another week to complete assignment number five. Shawnti wrote the extended deadline on the chalkboard before class started. Some male students who had stayed up late to complete the assignment were upset about the extension. One older man commented that the assignment was easy and he did not see the need for the extension. Of course many students gave the extended due date a "thumbs up" reaction.

Some people left Shawnti's recitation when they learned that the assignment was not due that day and that the next assignment, number six, would be handed out the next day in class. A handful of male students around the room were reading or doing other things that made it clear they were not listening to the lecture. After class I overheard a couple of men talking about how they had completed the assignment. They exchanged information about what had been helpful for them — the debugger and a C++ reference book.

Rick was gone on the sixth Friday and he arranged with Kyra to give the lecture in class that day. The topic of the day was a difficult topic to present, recursion. Once students saw that Kyra was giving the lecture, at least 20 students (all male) left. Assignment number six was distributed and it seemed that students who had not previously programmed would find little in the assignment description that they knew how to tackle. The assignment involved the use of recursion and C++ functions that were new to the students. The due date on the assignment was two weeks away but the students were used to assignments being due the next week. Most students did not take note of the date.

Kyra's discussion of recursion took 20 minutes as she presented two examples. A copy of one example was distributed to the class. The second example Kyra wrote on the board without explanation as to what the program was supposed to do. She did not trace any input through the program either.

Following this introduction to recursion, Kyra continued to discuss the two new functions to be used in assignment six. She used these two functions in a recursive piece of code similar to what would be needed for the assignment. Kyra's code contained an error in the placement of one of the statements. A male student pointed out this error and students grumbled a bit as they corrected their notes.

Kyra's code also contained a major logic error as she used a WHILE rather than IF to test the recursive condition. While tracing data through the code, Kyra started to become uncomfortable with the code. Two males started pointedly questioning Kyra and she became defensive. One of the students discussed the logic with Kyra for a couple of minutes. As the one student's discussion went on with Kyra, many students started to pack their bags and leave. After a few minutes Kyra looked up at me and I suggested that the statement should be an IF rather than a WHILE. Because she was so flustered by that point, Kyra did not understand my suggestion. Another male started questioning her logic as well. Finally she asked the students with questions to come up to the front desk to discuss it with her and she dismissed class. After class I received an e-mail note from Kyra in which she recognized her mistake and apologized for not accepting my help.

Kyra sent Rick an e-mail note about the Friday lecture. Rick came up to talk to me before class on the Monday that followed in the seventh week. He asked about the logic problem and what had been covered. He said he planned to slow things down and again go over the material that students needed to know to complete assignment six. Rick distributed handouts with an additional recursive example and corrected code for the example that Kyra had problems with on the sixth Friday. Rick spent the entire period talking about details for assignment six and reviewed and expanded upon the material that Kyra presented. Rick also reminded students that the examples they received in class closely paralleled the assignments. He emphasized the importance of reading the examples carefully and developing an understanding of the code.

Because Rick was out of town, no TA meeting was held the seventh week. Rick made no new transparencies for the recitation. He suggested that students probably had questions on assignment six and the recitation was a chance to "get in touch with where the students are at this point in the course and help them with problems that they are having."

Only about half of the students in Kyra's recitation were in attendance the seventh week. Kyra reviewed some of the functions used in assignment number six and talked about common mistakes in assignment number five. The students had no other questions so class was dismissed 25 minutes early. As Trent left class he told me he did not think that Kyra was very well prepared. Trent noted that the day's short recitation was not the first short session they had.

Kyra came back to talk to me after her seventh week recitation. She was at a loss about what to do when students did not ask questions. I suggested that she could always present more code examples. She said some students had complained last week that her examples gave too many hints for the programming assignment. The students complained because they had worked long and hard without the hints to complete their assignment. Kyra thought that since recursion was the program assignment she did not want to cover any recursive code. I suggested that there were many recursive examples different from the assignment that would still help students develop their understanding of recursion.

She understood but seemed at a loss as to how to teach with examples or come up with good examples.

Following the tenth week TA meeting I had a conversation with Kyra about my field of study, education. Kyra commented that when she was finished with her PhD she would prefer an industry job over teaching.

John's seventh week recitation also had only about half of the students in attendance. John used almost the entire class time to trace through example code, talk students through the logic of assignment six, and answer specific questions.

On the seventh Friday, Rick realized that students still did not have a good understanding of recursion. Rick spent 10 minutes with yet another example. In an attempt to focus on the logic of recursion, Rick used pseudocode rather than C++ for the example.

Rick's lectures in the eighth week included discussions of algorithm design and documentation and a demonstration of the debugger. On the eighth Wednesday Rick handed out the last programming assignment, number seven.

The second midterm exam was scheduled for the eighth Friday and on the eighth Wednesday Rick distributed copies of the prior year's exam. Rick again conducted a help session on Wednesday night. The session was scheduled to run from 7 pm to 10 pm. I was unable to attend.

Most of the eighth week TA meeting was spent in discussion of student difficulties. Related to the discussion of student difficulties, Rick stated that 90 of the students had at least two terms of experience with BASIC programming. Kyra thought about 30 students had no programming experience at all. The feeling was that most of the student difficulties with assignment six stemmed from students' eagerness to code and failure to plan. For this reason, it was determined that pseudocode was to be required before receiving help with assignment seven. Kyra mentioned that students had a number of syntax difficulties and suggested that it might be good if students had a C++ reference. A C++ reference was not made available for the course. Rick also mentioned that he was still receiving reports that TAs were not available during their office hours. The TAs again stated that they were in the lab but maybe just not found by students. Recitation

sessions in the eighth week were spent in discussion and review of details related to assignment seven.

One hundred forty-four students took the second midterm exam on Friday of the eighth week. Sixteen of these students were female. The exam seemed quite difficult to me as I read through it. Rick kept busy answering student questions through almost the entire 50 minute period. Only 15 points out of 75 points did not involve reading or writing pseudocode or C++. After 30 minutes only five students had left. Nearly 75 percent of the students were still working after 45 minutes and no females had finished after 50 minutes. At the 40 minute mark Rick commented to me, "They're either going to get 75 or 0. It depends on how good they are at solving problems." Rick allowed 55 minutes and then students were required to submit their exams.

After the difficult second exam I heard a number of comments, directly and indirectly, from students not officially a part of this study. One male turned to me as he was finishing his exam and when he realized that I was the person who was "taking comments from students" he told me what he thought. "I thought the test was too difficult. You can tell by the number of people still working when time was called. It was much harder than in class or homework." Another male student sent an e-mail note to Rick which Rick passed on to me. "I thought [the midterm exam] was very difficult and if I had a few more years of programming and more time to complete the test I might of come out ok. I just wanted to let you know that I thought I was prepared for this exam from our notes, and handouts given, but I have to tell you that I was pretty shocked by the exam." I learned of one male enrolled in CS 111 who, because of poor results on the midterm, was considering changing his major from computer science. I overheard another male tell a female student in class that the exam made him a little uncomfortable about how he would do in CS 112. Finally, after class on the Monday following the second exam, I overheard two males discussing the exam. I had previously noted from the questions these males asked in class that both of these males had prior programming experience. They felt that for the first exam the questions had closely matched the content and format of the study materials that Rick had distributed. They felt the second exam

was much different from the study guides and that if they had just studied the study guides then the exam would have been a surprise.

The ninth Wednesday Rick commented to the class about the second exam. "The exam was apparently difficult for a lot of you. Some of you apparently have had very little experience doing problem solving. Apparently I overestimated your abilities based on your performance on homework and the first exam." Rick told the students not to panic yet as he had told the TAs to grade the exams leniently.

Rick mentioned in class that someone had commented on the recursion question on the exam that the course was CS 111 not discrete math, "Why are we doing recursion?" Rick used this comment to lead into some informal advising. He spent about 10 minutes talking about why students were required to take math and physics as part of a computer science major. Rick also commented that the only real predictor of success in computer science was performance in math. He explained some about the subject matter overlap in math, physics, and computer science and talked of the problem solving experience and maturity gained in such courses. Rick commented that the computer science major had more elective hours than other engineering majors because they wanted students to learn about other disiplines so they were able to communicate with people in other disciplines as they worked with them.

In the TA meeting of the ninth week the discussion focused on the second midterm. The TAs were to discuss the midterm in recitation. I asked Rick what he expected to do if the exam produced a lot of exceptionally low scores. He said he probably would not decide until after the final. If 45 percent of the class received As with no adjustments made for the second midterm, he would not adjust for the low scores. Rick was disappointed in the student performance on the exam and commented again that he had overestimated the class's ability. He was surprised by how poorly they had done on the recursion question when the question asked them to do pseudocode for a problem like assignment six (which they had completed prior to the exam). Rick felt that the performance on the recursion question obviously meant that students could do the code for assignments without understanding the logic. I mentioned that some students did not

feel that the exam resembled the study guides closely enough. Rick thought the study guide and old exam closely mirrored the second midterm.

In Kyra's ninth week recitation she did a good job of working through the exam problems and explaining the solutions. She highlighted the similarity of the recursive question to assignment six. Exams were returned as the first exams had been. Student's scores were clearly visible as other students looked through the exams for their own. I overheard a female complaining about this technique the following day in class.

Rick was already in class answering questions when I arrived 10 minutes early on Friday of the ninth week. He answered student questions on the exam and assignment seven until class time began.

When Rick asked for questions before class began on Monday of the tenth week, the first question was whether a review session would be held before the final exam. Rick explained that he would be gone Wednesday through Friday of the tenth week (there would be no class) but he could do a review session from three until five on Friday. Rick distributed an old final exam for students to use as a study guide. Rick reminded students that the final exam questions varied from the questions on the old exam but pointed out how the questions on the old exam were similar to ones students had seen in the current term.

At the TA meeting on the tenth Wednesday, the last week of classes, Shawnti complained about how she had not completed any of her work that day. She had gone to the lab in the morning and answered questions all day from CS 111 students. Though she had fielded lots of questions, she felt that assignment seven was more manageable for the students and they were making progress rather than working without understanding.

Tenth week recitations were spent working through the problems on the old final exam. Problems which involved writing code were skipped because there was to be no code writing on the final exam. No code writing questions appeared on the final exam and most people finished the exam in 45 minutes to an hour.

The third interview with each of the student participants was conducted early in the first week of Spring term classes. Similar to my impressions after the second interviews, I was somewhat suprised at how well the third interviews went. Following

Eddie's interview, he commented that he really looked forward to the interviews. It was clear that all of the students were relaxed and seemed to enjoy the interviews.

One morning during the first week of classes of Spring term I talked with Rick for about 45 minutes about his experiences of Winter term. I started by asking Rick to reflect on how he felt the CS 111 course had gone. "Based on the performance on assignments and based on the performance on the final exam, I had 40 As out of 155 students so it's more than a quarter As which is a pretty high percent for me and there were also a lot of Bs. So I think the students, I don't know how they perceived it, but I think they learned quite a bit."

Rick said he had not adjusted for the low average scores on the second midterm. Since 25 percent of the students had earned As he did not think anyone needed an adjustment for something that was a fairly small proportion of the course grade. (There were 40 As, 41 Bs, 42 Cs, and 30 grades below a C.)

Rick continued to talk about the large class size and associated problems, acknowledging the lab situation as a problem. The minimal access to the necessary computing resources had caught Rick by surprise. Rick had incorrectly assumed that all computer labs on campus had updated their compiler software to the version used for CS 111.

Rick said that the background survey results had surprised him with the amount of programming expertise that the students brought to the class. He was overwhelmed by the student experience but when asked he did not remember what percentage of the students had no experience.

> I thought I had tracked them pretty well until we hit the second midterm. Then we backed off and we did not cover as much as I had in previous terms. I did more programming last time. I did more algorithm stuff this time than I have in the past. . . . I think the students didn't pick up this time as well probably because, [pause], a lot of them hadn't had it in their experience and I thought they would have, had they had all that programming stuff. . . . The assignments were pretty much the same. The class was bigger. This is by far the biggest class that I've taught for this particular course. And that may have slowed things down too.

I asked Rick how he felt about the balance in the course between programming and computer science concepts.

> Actually what we're doing [next year] is we're adding another course to help them out because it is an awful lot to cover in one term. That's why we don't get very far in the programming language stuff. . . . A lot of the design stuff and a lot of the software engineering stuff, and some of the computability stuff, so we'll be able to spend more time on that, will be taught in [the new] course. So that what we'll be doing is, in a sense they'll have an introduction to computer science as a field.

Rick felt that in the Winter term course he had spent more time discussing programming details with the students than he had when he had previously taught the course. He felt that part of the reason for the extra programming discussion was because there was no C++ text for the course. Rick was of the opinion that the C++ texts used in the past had not been good. Rather than use a bad text, Rick decided to spend more time presenting the material in recitations. "We gave them handouts and they got quite a bit of sample code which is really the value of a textbook I think. And they always got code that was related to the programming assignments, although they had a hard time seeing that sometimes."

I asked Rick how he felt about his contact with students. "I spent two hours a week, something like that, over in the lab every week. That worked out really well. That got me to see where they were having problems which led me to help develop what went on in recitation at least and sometimes what went on in class. And that's always helpful."

I asked Rick to reflect on his involvement in the study or how he thought my involvement might have affected the course of events.

> I appreciated your comments all along. . . . I would have appreciated it if you had been in a position where you could have been a little bit more open. . . . It would almost be nice if there was someone permanently in your kind of capacity who could be a [liaison]. I think both for the students and the faculty if there was someone like you, if we could have someone permanently like you who could read the students and then turn around and offer constructive criticisms. One of the problems is that

students don't often do that. That is, when they're upset about something they just scream at people.

The Student Experience

All of the student participants, except for Heather, were on campus a few days before classes started in the Fall. I arranged with the students to meet together for an hour long session where I showed them how to use the campus e-mail system. The e-mail training session was my first chance to meet the students and it also gave the students a chance to meet each other. The training session took place on the Friday before classes started on Monday. Devon forgot about the session so Samantha, Trent, and Eddie were the only students in attendance.

Heather's Experience

Heather moved into her room Friday and Saturday before classes started on Monday but was not on campus until the Sunday before the start of classes. Because Heather was not able to attend the Friday morning e-mail training session arranged for the student participants, I met with her Sunday afternoon in her room in the WISE wing of the dorm. I helped Heather configure her computer's communication software and explained how to use the e-mail system. The initial interview was also conducted during our Sunday afternoon meeting.

Heather did not have a roommate and spent considerable time decorating and taking the institutional edge off her dorm room. I learned as the study progressed that Heather enjoyed decorating her door for holidays and after a few weeks of living in the dorm Heather was looking forward to painting the hallway walls "to give more of a homey feel to the place, which it desperately needs."

When I first met Heather and walked into her room, I immediately noticed that the room was filled with technology. Heather had a television and video cassette recorder, a

dorm-sized refrigerator, an elaborate portable stereo system, a collapsible bicycle, and her computer setup. Her computer was a portable laptop computer with an external keyboard and large color monitor and laser printer attached. As we talked Heather also mentioned that both of her parents had cellular telephones. Apparently Heather's family had money to buy technology and it was a priority to have the technology available.

Consistent with my telephone conversation with Heather, Heather was not very talkative as we spent time together in person Sunday afternoon. Heather initiated little conversation and provided one or two sentence answers to any questions I asked. Only when our conversation turned to technology did Heather's conversation become more animated and relaxed. Heather said she liked to "try and make things work. Sometimes it's fun not to read the manual and figure it out."

Heather and I ended up spending two and a half hours together before we had her system up and running and she knew how to use the e-mail system. As we talked during this time Heather never mentioned any friends her own age. She talked about her brother (who was two years younger than Heather), her dad, and teachers at school.

In this first meeting I learned that Heather's dad was the chief executive officer and a computer programmer for a company that manufactured electronic equipment. Heather was first introduced to computers 10 or 15 years earlier when her dad brought a computer home from work. "I don't know why he brought it home, just to kind of entertain us."

Heather was confident in her abilities to use a computer because she had been around computers at home and done well in programming classes in high school.

> It was kind of fun just doing BASIC on [the first computer dad brought home]. You could make it do neat drawings. I had a computer in my room, my own computer, for like five years and then two years ago I took computer science at high school and did BASIC and aced that class. And then next year I took an independent study for senior year in Pascal and aced that. It's just so much fun because you get to work things out. You kind of see how things pop up and do weird things.

Heather felt that she did not have a good understanding of the work computer scientists might do although her dad was a programmer. Heather's interest in computer

science was in programming. "I think computer science is learning how to do that neat stuff you see happen. I'd like to be able to do that neat stuff."

Heather's college choice was also influenced by her father. When asked why she had chosen to attend the University, Heather said, "My dad went here for like a year and a half, he didn't graduate, so he either chose this school or [the school] where he went to in California. And I'd rather stay in state so I went to here."

Heather indicated that mathematics was "not her favorite thing" but she had worked to make sure her mathematics background was adequate. When asked about her mathematics preparation, Heather explained:

> Well, it's interesting because I started out in general math and if you went four years through high school with it you wouldn't get up to where it would be [pause], you wouldn't graduate with a college prep. I ended up taking two years of math my sophomore year. I pushed myself through one year in like three months and did the other in the rest of it. But I ended up in advanced algebra and then I took a pre-calc class this summer [at a community college].

Heather seemed to have little information and few preconceived ideas about what her college experience might be like. The computer science department advisor was the only person she had talked to on campus. All that she knew about the courses for which she was enrolled she had learned by looking through the textbooks she had purchased for the courses.

With the knowledge that Heather's father worked for a computer-related company, I assumed that he had Internet e-mail access and his access would encourage Heather's use of e-mail. I later learned that Heather's father did not have Internet mail access through his work. A few months later, with my help, Heather arranged Internet access for her dad from home.

During the first week Heather signed on to the system at least once daily but the next note she sent to me, after her note the first Monday evening, was her first week's journal entry on Saturday. She thought classes were "okay." "The hard part this week is finding exactly where my classes are, especially finding the stairs. I'm amazed at the big

classes, I'm not use (sic) to having that many people in a room. . . . Overall my week has gone well. I'm getting my bearings of [the University] as well as [the University town]."

Heather felt that the lab exercises for the computer science class were easy for her. She was considering taking some of the weekly lab quizzes early and getting them out of the way. Heather also commented that she appreciated the fact that the textbook for the computer science class was up to date rather than talking about huge computers and tape drives like the textbook she had used in high school.

Thursday of the second week I sat in on Heather's morning lab session and spoke briefly to Heather as she left. Later in the afternoon that day, I discovered that Heather had asked me a couple of questions via e-mail but she did not mention her questions when I saw her after her lab. Heather had sent her questions before her lab and had signed on to the system after her lab, perhaps looking for answers. One of Heather's questions concerned how to access the library CD-ROM system from her computer. She also wondered if I had any explanation for why her system login password was reset. It had taken her 18 attempts to finally figure out that she should try using her old password (which worked). "It was very frustrating!!!!!!!!" I provided Heather with some information in response to both of her questions. This question and answer exchange was to become a familiar occurrence in the weeks ahead.

On the following day I sent Heather an e-mail note asking for some help. As a part of some of my work I was asked to contact a computer vendor in Heather's hometown but I did not know the name of the business. Heather provided me with the name of the business and gave me the telephone number and location of the business.

Saturday of the second week Heather sent her second journal. Heather reported that the week had gone "sort-of well." She was trying to study for a midterm coming up in chemistry. She commented that "Math is ok, [it] reminds me of geometry with having to prove everything."

Heather also characterized CS (the computer science class) as "okay." "I aced the lab quiz, but I haven't got around to asking about taking the other quizzes. I'll probably do that this week. The only thing I need to review in lab is Hypercard 2. I haven't played with that for years. I got MS Works so I can work with it at home. The lectures are

okay. It's just reviewing the reading in Computer Current [the textbook], so I can just follow along in the book with my highlighter."

Heather stated in her journal that she was suffering from a cold but her week had gone okay. "I'm becoming friends with my neighbors and learning the ropes of dorm life. I've finally staked out a good video store for entertainment and a few fast food places."

After Heather sent her journal on the morning of the second Saturday, she signed on to the e-mail system several times Saturday and Sunday before I sent a reply to her journal Sunday evening. I felt badly that I had not replied more quickly and wondered if her sign ons were in search of my reply.

In the third week as I went to class and lab sessions I observed that Heather was feeling comfortable about her knowledge of the "hands on," use of computer applications, material covered in the computer science course. Monday in class the instructor presented a demonstration of the Microsoft Works word processing program. There was an opportunity for those students comfortable with the material to leave. Heather left class. A week later Heather also left class halfway through the basic spreadsheet demonstration. Tuesday I went to Heather's lab session. Heather took one quiz and asked the TA about other quizzes. I did not speak to Heather but got the idea that she would have taken more quizzes had they been prepared.

On the third Wednesday I sent a note to Heather to ask how her week was going and to tell her that I had contacted the computer vendor she had identified for me in her hometown. In the afternoon Heather sent an e-mail note with some small talk about her week and told me that she had talked to her brother some more about other computer stores in her town that might have what I needed. In my reply to her note I asked if she used e-mail to communicate with anyone else. I was curious because by this time Heather signed on to the system about three times a day. Heather did not respond to my question about her e-mail use. I asked Heather the question again two weeks later and she said that I was the only one she communicated with via e-mail.

Also during the third week I developed the impression that Heather prepared for her computer science class and enjoyed the class. She followed along highlighting in the textbook during the class lecture but some material was already marked in her text before

class, presumably she had done the assigned reading. Heather commented in her week three journal that some students thought the lectures were boring because they just followed the book but Heather said she did not mind. Heather had completed two lab quizzes during the week and said she was pestering the TA to make sure that the next quiz was ready the following week. Any "practicing" necessary for lab quizzes Heather said she was doing on her own computer in her room. Descriptions of the bonus projects were distributed in the computer science class and Heather thought the projects looked easy, "getting bonus points isn't going to be hard."

Heather sent her third week's journal Friday afternoon, after expressing concern in her previous journal that this journal might be late. She wrote as she waited for her parents to come pick her up for the weekend at the beach. Heather's journal included some small talk and was about one single-spaced page in length. She commented that her journal was a bit long and indicated that the length was due to the fact that she was a little bored the day she wrote it. "Mail, in any form, has been a great distraction from the grind of school work (next to TV)."

Heather reported that her cold was better but she was behind on work that had not been done while she was sick. She also indicated that she had scored a 64% on her first chemistry midterm exam. Heather was considering changing the grading for the chemistry class to Satisfactory/Unsatisfactory. Heather enrolled in Chemistry because she enjoyed the course in high school. After three weeks of college Chemistry, however, Heather commented that "[chemistry] isn't as fun as I remember it. I guess I like doing the experiments and seeing the reaction first hand [more] than doing all the book work."

In her third journal Heather said that classes were going all right and she was doing some research for a paper on computer crimes for her writing class. She had used her computer in her room to search the university library's online catalog and CD-ROM network. On the following Saturday Heather spent the morning in the library gathering resources for her research. "I've been in there just on the main floor so I was kind of amazed at it on the other floors. In fact I got lost looking for some of the books I needed."

Heather's comments, questions, and sign on patterns made it clear that she enjoyed making use of her computer and the e-mail system. I noted that she signed on to the system Saturday while she was with her family at the beach. Sunday of the fourth week the e-mail system was unavailable most of the day but Monday Heather signed on to the system at least five times. Heather and I exchanged six electronic notes on Monday. Weekend discussion with her father had prompted Heather to inquire how her dad could send her e-mail and access the campus library online catalog.

Wednesday evening of the fourth week Heather sent a note to tell me that she had crashed her bicycle in the afternoon on her way to class. Obviously, not even a bicycle accident kept Heather from her e-mail. She was taken to the hospital with bumps, bruises, and a fractured rib but avoided major injury.

> Now I have to figure out what I missed in Math (I have a mid-term in that class this Friday) and make up a quiz for Chem. lab I missed. But I'm not worrying about it until tomorrow. Plus my only form of transportation (other than walking) is gone until Sunday (my mom is going to bring my other bike down for me). Well, I'll stop pestering you for now. This is the only thing that doesn't require too much bodily movement.

Heather's comments were the first real mention Heather had made of her mom. Heather reported in her Saturday journal for the fourth week that she had searched through the computer and located e-mail addresses for her math and chemistry recitation instructors. She wrote them via e-mail to check on work she had missed because of her accident.

Friday of the fourth week Heather had midterm exams in her computer science class and in her math class. Heather completed the computer science midterm in 25 minutes and thought she had done pretty well. "I had a mid-term in math. It was ok too. I tried my best on it, I had a hard time trying to get one of the problems figured out. So, I ended up just 'playing' with it and hoping to get some credit for trying the problem."

After four weeks I felt like I was getting good information from Heather. I also felt that for Heather, who had little to say in one-on-one conversation, e-mail provided a great way to get information that I probably would miss otherwise. Heather continued to sign on to the e-mail system three to five times a day. Clearly e-mail was important to

Heather. When I notified all the research participants of my new e-mail address, Heather re-sent a note she had sent to my old address so I would be sure to get it. Heather also spent some time designing faces out of ASCII characters and occasionally included these faces in her notes.

Heather had a technology-related question for me every three or four days during Fall term and between the terms while she was at home. Heather's questions arrived about every two days during Winter term. Usually the technology-related notes were not confined to the question at hand but also contained a few words about life with Heather; therefore, Heather's frequent questions meant that I was well informed about how things were going for her.

A few minutes before class started on the fifth Friday, the CS 101 instructor was talking about the hacker attack on the computer science department machines. Heather listened intently and took notes (not a usual occurrence). She took notes so she could use this example in her writing class paper on computer crime.

Heather did not send her journal over the fifth weekend but I caught her in the hall before class on Monday and asked about her weekend. She spent the weekend studying for her chemistry midterm. If she did well she could throw out the first exam. Heather said that the hard part of studying all weekend for chemistry was staying away from the computer, although she had still signed on to the system three times Saturday and twice Sunday. By Monday evening Heather had sent me three notes (one apologizing that I had not received her journal yet). Since she seemed to have returned to her regular computer-use patterns, I asked Heather if her chemistry test was over. "No, it's tomorrow night. I'm just giving the brain a rest for a little while."

Heather's journal for the fifth week arrived late Monday night of the sixth week. She characterized the week as "sort of ok."

> A majority of the problems that made my week that way were brought on by myself. First I flunked my math midterm. Then I have been doing awful on chemistry quizzes. Both of these things happen because I've been watching TV and playing with my computer too much. So this weekend I locked myself in one of the empty dorm rooms and studied math and

> chemistry for most of the weekend. Now I'm thinking of a new strategy at studying and getting the work done that needs to be.

Heather still reported that "CS [was] ok." She had finished two lab quizzes that "weren't too hard" and had done "alright" on the CS midterm (84 out of 125 points). She had a discussion with Aaron about a question that was graded wrong on the midterm.

In response to Heather's comment about flunking the math midterm, I offered to send her a copy of the TA hours of availability in the Math Learning Center. Heather responded and I sent her a copy. I also sent Heather a note about a meeting of the student ACM chapter. The main topic of discussion was to be the hacker attack on the computer science department machines and I thought Heather might make use of the information in her writing class paper.

Heather went to the ACM meeting and the day following the meeting she sent me a note wondering if I could meet her to talk about some questions she had from the meeting. I met with her the morning she sent the note and talked with her about her questions and notes (which she had typed). Heather's questions were about the UNIX operating system and the commands that the hacker had used. She felt that the others at the meeting all seemed to understand so she did not want to ask her questions at the meeting. Heather had taken a female friend with her so she would not be alone at the meeting. Heather said that they were the only women there and she was somewhat intimidated. Heather and her friend left after the hacker discussion so they could avoid the social scene.

In our conversation following the ACM meeting Heather talked about the Women in Engineering dinner she had recently attended. Heather indicated that going to this type of function did not interest her much but it gave her an excuse to leave her room. She had a chance to talk to her (female) math professor at the dinner. Heather explained to her professor about her biking accident that occurred two days before the first MA 201 midterm. Heather felt the professor was understanding and it could mean some flexibility when grades were determined. Heather had scheduled an appointment with her professor to discuss the midterm and other questions.

Also, as a part of our discussion on the day after the ACM meeting, Heather told me that she had not done much better on her second chemistry test so she was going to change the class to Satisfactory/Unsatisfactory grading and maybe it would give her more time to study math. Heather mentioned again that she needed to learn to manage her time better, like not watching so much television.

As the seventh week started I sent Heather a note that asked her to identify her talents or abilities and whether she was applying them or not at the current time.

> Most of my plant-related talents (landscaping, flower arranging, nursery and greenhouse production) haven't been in use around here at all. I think the only skill that is plant-related that I've used here is trying to identify some of the neat trees and plants around campus. I miss working outdoors and doing stuff like that.
>
> As for computer talents, I've been using a majority of my word processing, spreadsheet, and my computer art skills. I've been also using my exploring skills with the computer at the CS lab. I like to go through a computer trying out all the applications and seeing what they do. One talent I haven't used around here is writing computer programs.
>
> Another ability that I have used a lot around here is procrastination. I wouldn't call it a good ability but I've found that I used it a lot.
>
> I also like to build things with wood. Leave me with a pile of wood, a hammer and nails, I'd try to make something with them. But I haven't used any of those skills here at all.

Heather's journal submissions were always on time or, if they were going to be late, she sent a note. Her week seven journal was late but "would have been on time if the [e-mail] system wasn't down this weekend." There had been midterm exams in the computer science class and math class during the past week. Heather felt that the C she had earned on the math test was rather good and a major improvement. She thought she had done "okay" on the CS exam. The next week she reported that she had done "pretty good on it, 110/125."

In the eighth week, Heather sent me a note with a couple of personal questions. I had mentioned playing on a basketball team and she wanted to know more about it. She also wanted to know more about the process of earning a PhD and wanted to know what I planned to do when I finished. "If you can't answer them for some odd reason [because of

the research] I'll understand." My answers to these questions gave Heather more insight into the person I was and seemed to be, for Heather, the basis for a new level of trust in our relationship in the weeks that followed.

The first item that Heather reported in her week eight journal was that she had been having problems with her computer. She spent part of her week talking to her brother and working on some problems. Most of the rest of her one page journal talked about what was happening in the computer science course. She had enjoyed programming in HyperText for the Hypercard lab in CS. "It's kind of neat [and the result] was cool looking." There had also been a lecture on artificial intelligence in class that week. "The artificial intelligence section sounds both kind of neat and spooky. It's neat in a way that they could help a disabled person but [having a computer ask you questions] is strange. I'm afraid of the computer thinking that I'm an idiot and decides to do something drastic to me. Oh well, humans will always have the power of unplugging the computer (I think)."

Heather was signing onto the e-mail system four to six times a day by the ninth week in the term. As she waited for her ride to pick her up for Thanksgiving, she sent a female friend from the dorm and me an ASCII art picture of a turkey. Friday Heather dialed into the system from home. Sunday night Heather needed a break from her school work so she sent me a note that asked for some clarifications on my response about my PhD pursuit.

Two and a half weeks before Thanksgiving Heather said she was looking forward to going home for Thanksgiving. Heather's journal for the ninth week arrived on the Monday after the Thanksgiving weekend. Heather reported on her Thanksgiving weekend at home.

> I think I've figured out why I always liked going to school, to get away from the house. . . . I made the mistake of mentioning that I had some homework to do, so I ended up being asked every hour or so if I was doing it, which really annoyed me. . . . I guess the thing I really enjoyed this weekend was spending some time with my brother. He was kind of glad I came home, mainly to get our parents' attention away from him. . . . He did help me out with my computer problem; it was some system error.

> I finally got that computer crimes paper done. I was telling my dad about it and he mentioned that he wanted to take a final draft of it to work with him.

Heather had completed registration for the next term's classes while she was at home for Thanksgiving. "I amazed my parents by saying that I had to register. I guess they thought I wouldn't stay here for more than one term. . . . I think mainly they thought I was going to find out what college life was and go, 'I don't like it'."

One lecture in the computer science class the ninth week was a demonstration of Mosaic, a multimedia tool for browsing the Internet and World Wide Web. Heather talked about it in her journal. "That multimedia 'extravaganza' was cool looking. It looks like something that I'd like to explore sometime."

During the tenth week Heather ended up adding some material from the ACM meeting to her computer crimes paper. She asked me for further clarification on a couple of items. We also exchanged several messages as she tried to locate an e-mail address for someone on campus. Just as Heather conscientiously submitted her journals each week, she was the one to ask me about scheduling the second interview of the study. The tenth week included several messages to schedule an interview time and location.

Heather's tenth weekly journal arrived the weekend before finals week. "I'm not as worried on the CS final as I am on the Chemistry and Math finals. Math will be my big stressor of the coming week. I want a good score so at least I will get a decent grade for the course. I haven't had any real problems with the stuff we're covering now, but I really have to review the stuff from the first of the term to prove that I finally caught on to the things covered in the mid-term I screwed up on."

Heather also reflected on the term in the computer science course.

> CS 101 was a pretty easy class for me since that I've been around computers a lot. But I can understand why other people had trouble with the class. It has probably been the first time that they have been formally introduced to a computer and it takes a while for a person to learn all the things that a computer does. . . . I aced all the quizzes. So, my outlook on my grade in the class should be in the A B range, which will make my goal I set for myself for the term (to get at least one course with an A in it).

During finals week my exchange of messages with Heather concerned how to obtain a pass to university sporting events and a question about an error message from the e-mail system. I also asked Heather to explain a comment in her week ten journal, "Well, this term is pretty much over and in some ways I'm glad it is." Heather said that the positives were the vacation and break from school work. The negatives were:

> (1) I kind of wished we had more time in CS 101. There was a lot of neat things that I found out in that class but to me it was rushed through very fast and we didn't get to the end of some of the chapters. So, it left me hanging there on some of the subjects covered in the class. (2) I really don't want to go home. During the Thanksgiving break I have found that I don't have much of a life there. Where as (sic) I have a life here, and I like it. I guess if the friends that I have made here didn't leave and the residence hall wasn't closing, I would probably stay here and maybe spend only a week at home.

Heather left campus Friday of finals week and Sunday she signed on to the e-mail system from home to send me a note. Her dad wanted her to get Internet e-mail arranged for him while she was at home. Heather asked that I send again the information I had given her in October about possible sites for Internet access. Heather signed on daily from home and we exchanged messages about Internet access and other of Heather's questions throughout the December break. In one of her notes Heather mentioned that she and her dad were going to make a trip to the University town over Christmas break. Heather was going to buy her books for the next term and her dad wanted to visit bookstores in town.

I met Heather in her dorm room for an interview the day before the second term of classes started. I asked her how she felt about her grades from the first term (CS 101: B, MA 201: C-, Chemistry: S, and an A and a B in her other baccalaureate core courses). "Oh, it was okay, good news." I asked Heather why she thought the math course was such a problem. "I think it was just mainly because I snoozed half of the term and then went, oh, I'd better figure this out!" The first term of discrete math had been frustrating for Heather as she worked to "get [her] act together on doing math and tried to figure out what was supposed to be learned." She hoped the second term of the math course would

go better though because when she started putting more effort into MA 201 in the Fall things had gone a lot better.

When I asked Heather what adjustments she had to make her first term of college, she talked some about her study habits. "Well, other than figuring out that I'd better start studying and not watching television half the time. . . . I did have homework [in high school] but I didn't do it and then I'd always pull a hat trick and get out with some good grade but here you can't do that. Hat tricks don't work here!"

I asked Heather to reflect on how she was feeling with her choice of a computer science major. "I'm pretty comfortable with my major right now. I still like the programming part. But I was just looking through the computer science book for next term and it was saying in the introduction that most people's idea of computer science is programming. Nobody knows what else it is and I guess it would be kind of interesting to find out the other."

I asked Heather if she had enjoyed living in the dorm and getting to know people. "Well, at home I don't have that many friends. I have friends here that at least on this floor everybody's kind of doing the same thing and that's kind of nice. Like a few friends we had chemistry together so it was kind of easy to knock on someone's door and say, 'Hey, can you help with this?'"

As in the first interview, Heather's conversation was most animated when she talked about computers and technology. Over the course of the first term Heather had unofficially taken on the role of liaison for technical support of the MS-DOS (Microsoft Disk Operating System) based machines in the resource room of the WISE dorm wing. We talked some about the current nonfunctional status of those machines. Heather also talked in some detail about the computer-related "toys" she and her brother received for Christmas. "My dad gives cool toys. My mommy usually gives us the books and stuff and my dad goes and buys us technical toys."

I asked Heather about her mom's interest in technology.

> My mom has a computer. It's collecting dust down in the basement. I think she only turns it on once a month to do something and then turns it off. We all offer to help but I guess she hasn't really found an interest in it

> as much as we have. . . . I think we kind of intimidate her, you know, we know too much. But at least she's nice enough to let [me and my brother] discuss like computer stuff and she'll just sit there and nod her head and hope we're right.

Heather's conversation was also relaxed and free flowing when she talked about her brother. "I guess he had fun having me around. He's coming down in a month for a couple days. I get to show him around. He's a freshman [in high school]. He's learning disabled so [I] help him out."

As the interview finished, I thanked Heather for her willing involvement in the research. She commented that, "It's kind of neat to have somebody to ask strange questions." She had expressed a similar sentiment in a note a few weeks earlier as well.

Heather started the new term in much the same pattern as the Fall term. Her first journal of the new term began with the following comment. "Why is it that when there isn't school work to do that there isn't anything to do, but when there's school work I find a lot of other things to do. Remember in CS 101 when we were shown Mosaic? After getting a copy of the [necessary communications] program and a little exploring, I can now run it on my computer. I have enough distractions from school to last me well into the term."

Heather's commentary on the new term's computer science class after one week was that "CS class is OK. This course seems like new material that's being taught and less review. It's going to be interesting to see the different fields in computer science."

Heather had the same professor for the second term of discrete math as she did for Fall term. Heather had talked to her professor about the trouble that some students had with the course the prior term. "She [the math professor] mentioned that people who take MA 201 during their freshman or sophomore year have a harder time with the class than people that take it during their junior or senior year. It's interesting to hear that because the way that the CS department does the prerequisites and corequisites a CS student has to take MA 201 their freshman year if they want to take CS 111."

In the next week, 26 messages traveled between Heather and me. A more typical week included six to eight messages. She had questions about campus sporting events,

technical questions related to the new computers in the resource room and her computer's memory, and questions about my sign on patterns as she had fingered me on many different machines and accounts. Heather also modified her "plan" (information displayed when using the UNIX finger utility) and had questions about when the plan was displayed. Her dad's new Internet account was not working right and after a few notes I told her I would meet her sometime in the next couple of days to resolve the problem. She had a day where nothing went right and I asked her to tell me the story. Another evening she was "bored" and sent me a note of small talk.

Also during the second week of winter term I asked Heather to give me a description of a course she was taking. Heather was enrolled in a leadership class for persons interested in the residence hall system or interested in being resident or peer assistants. "The main reason I'm taking the class is just out of curiosity of the resident hall system, all though [sic], the thought of becoming a PA [peer assistant] for the engineering floor has come to mind."

Heather's second week journal started with the comment that she had been busy with a variety of activities the past week. "Aside from trying to be a student, I've been technical support for people. Mainly just helping people figure out the new computers we got. Although I have limited DOS skills, some people just want a person to tell or show them that they can't really hurt the computer by just poking around in the computer (unless they erase it or something)." Her closing comment of the week's journal stated, "Amazingly I have been able to balance school and distractions this week (surprising myself)."

Heather thought that the computer science course was "going good" after two weeks. "It's also nice to have an instructor (both in class and for recitation) that is a little more down to earth than CS 101." (Heather had commented that she thought the instructor for CS 101 was "too darn happy about what he's doing." She thought her CS 101 recitation TA was a little strange and he was often absorbed in reading a book thus making it difficult for students to get his attention.)

> Programming in C++ is different than past language but the same style is required. . . . It's kind of weird not having a book about how to program

> in C++. I have manuals but those are written like I know how to program in C++ and I'm just using them for reference. I pretty much taught myself how to write in Pascal and BASIC from books on how to write in those languages, and just had a teacher to give programs to write and answer questions that I might have.

Heather had yet to mention the math course in the second term. When I asked her if MA 202 was under control, she said, "I'm trying really hard to keep math under control. So far I'm doing okay and I'm understanding what's happening."

Following the third week of the term Heather reported that "CS is going ok. It was nice of [Rick] to go over a program like the second assignment. Even though I had it done, I was glad that the way I did it was pretty much the same way he did his."

Heather's third week journal also included some comments about her dad and brother. "I introduced my dad to the world of e-mail and now experience all the different questions he has about it. (Kind of knowing how you feel, going to my mailbox and finding a few messages saying 'how do I do...') My dad is coming down for a few hours Tuesday to do some business and check in (sic) how I'm doing. My brother is coming down for the weekend sometime Friday afternoon."

In the week that followed, Heather and I exchanged notes in what had become the usual pattern. Heather had read the electronic newsgroup for the computer science department announcements and wanted some clarification on what she had read about the upcoming advising week. As she studied for the midterm in computer science she asked, "Where in computer science or life in general will I use octal or hexadecimal numbers (other than on my midterm)?" The pattern for our e-mail exchange had also grown to include Heather expressing her appreciation for my help. "It's kind of neat to have someone to ask questions to that knows what's happening." Heather also acknowledged that the volume of her questions could be high from time to time and she appreciated my tolerance of her questions.

Throughout the term Heather seemed to recognize problems in her study habits and was more aware of how often she was distracted from her studies. As midterm exams approached in the fourth week for her computer science class and math class, Heather commented that "I got to really study this week and not let too many distractions get to

me." In her journal following the exams she observed that "The last week has been stressful for me because of the pressure I put on myself to be successful in both CS and Math. . . . I'm glad the stress of [the exams] is over for a couple of weeks. The tests themselves went ok. I felt like I knew the stuff in them, just hope that I knew the correct stuff."

In usual fashion the fifth week included an exchange of messages with answers from me for Heather's questions. The main topic of the week was where to find Internet reference material and how to handle the file formats of the references so that Heather could print her own copy.

I noticed at recitation the fifth week that Heather and Samantha, the other female student involved in this study, were talking. They talked some about Samantha's programming assignment. Midterm exams were returned in recitation with the entire group of midterm exams placed on the table with all names and scores visible. Students went through the pile to search for their exam. Heather picked up Samantha's exam and also her own. Throughout the remainder of the term, in the computer science class and recitation, Heather and Samantha clearly exchanged information and helped each other.

In her fifth week journal Heather reported that "midterms turned out ok. The good news is that I passed both of them. The bad news is that I should of done better on the CS midterm. I knew what I was doing, I just got things mixed up. I messed up on one problem on my math midterm and I'm planning to see the prof or TA on it Monday."

Heather had sent one of her fourth week notes at the same time as the review session for the computer science midterm. Following the midterm exam I asked her if she had gone to any of the review session. "I didn't go to the CS review session, but I should of gone. I kind of forgot about it and by the time I realized that it was going, I didn't feel like [riding] my bike over to [the building]. But as I think about it now, I should of just went."

Heather expressed in her week five journal that she greatly enjoyed her residence hall leadership class. "My presentation on creativity and time management went very well. . . . My group instructor really liked it." Heather also felt like the computer science course was going all right.

> I'm kind of getting tired of playing around with the same program every week but then if I was working on this program in real life it would be the same as having an employer ask me to add something to a program I've written.
>
> It's nice to have the advantage of knowing other programming languages and the logic that goes into writing a program. I didn't realize that until I've been helping out Samantha with getting an idea of how the program should be set up. . . . I haven't really learned anything new about programming yet. . . . It's just kind of like translating one language to another and they [Pascal and C++] are fairly similar.

Advising week was approaching and, in her journal, Heather was looking forward to her advising visit. "I'm going to see my advisor this coming Tuesday. I'm not too excited about going to see him (about as excited as I would be if I was getting my teeth pulled). Hopefully it will be quick and painless." When I asked Heather to elaborate on why she felt this way, she said it was because her advisor had not been much of a help the last time she saw him.

Heather's fifth week journal also included a report on the status of the computers in the resource room of her wing of the dorm. It was clear from her comments that she had been involved in many discussions with the technical support persons. Heather was following up on several items to make sure that the computers were set up as they should be.

I was out of town for a couple of days during the next week. Heather continued to send messages and questions. Heather knew my usual responsiveness and sign on patterns and after 36 hours she sent a message wondering where I was and why I had not signed on.

Heather's week six journal arrived Wednesday of the following week but was preceded by many apologetic notes. Heather sent me daily notes to assure me that her journal would arrive. When it did arrive, she thanked me for being understanding about the journal's late arrival.

> Once I get this to you last week will be done with and in the books. Unfortunately this week has started without me. Last week was kind of a mixed bag of good and bad things. Tuesday night I finally got my new

> computer. Now I can run C++ [without running out of memory]. The other pluses of it are that it runs a whole lot faster and I have an even faster modem. So I spent a couple nights setting my new one up and transferring my files from the old one to the new one.

Heather seemed to enjoy the computer science class. "We got a new challenge now [recursion]. It's kind of fun to learn a new thing to play around with in programming. I like how we're interweaving things from what we're 'spose to learn in the class and applying them to the programs. I guess it's because I learn something easier when I can apply what is taught right away [rather] than to store it in my head for future use."

Heather enjoyed supporting others in their computer use. She reported that she was still providing Internet support for her dad and was keeping an eye on the computer situation for her wing of the dorm. Heather and I exchanged messages about the WISE computers during the seventh week and I went over to the dorm one day to assist Heather with a problem. I identified the problem and Heather continued to work with technical support on a solution.

In the week seven journal some of the edge of enjoyment was gone for the computer science class and Heather's review was that "CS is ok. The program [involving recursion] was kind of hard to figure out at first but after all the hints [in class and recitation] and a night of trial and error I have a working program."

As for her other classes, Heather talked about her residence hall leadership class with much enthusiasm and enjoyment. As for MA 202 Heather reported that she had earned a "pretty good score" on the math midterm. Heather thought if she continued to do well on the final and quizzes "I should get a pretty decent grade in the class." Heather also told me that she would need to retake the first term of the math course since grades below a C in required classes are not accepted for the departmental junior and senior year professional program. Heather had earned a C- in MA 201.

The message exchange of the eighth week included updates on the WISE computer situation. Heather also asked me about a concept covered in the computer science course. I pointed her to the appropriate section in the text (many chapters removed from the current reading). At one point in the week Heather made a comment

about being unsure whether I cared to know certain things or not. I assured her that if it was something that was important to her or something she was thinking about then I was interested. Heather appreciated the clarification.

Heather's messages through the eighth week indicated that she was thinking about jobs for summer and the year ahead. She asked if she could use me as a reference and I told her I could do so once the study had concluded. She also asked me if I could suggest the type of work with computers that she would find to be "fun, somewhat challenging, and probably a good learning experience." I pointed her to some electronic campus newsgroups and the computer science department bulletin boards and mentioned the kinds of information she might find there.

The difficult second midterm for CS 111 was on the eighth Friday. Heather turned in her exam when time was called after 55 minutes. In her week eight journal Heather described the computer science midterm as the "big crash" in her week. "I have a feeling that I majorly blew it. But it's all over with and I shouldn't worry about it now. I should just concentrate on the last program and the final, and do my best on each of them then I should be okay. . . . I guess the thing I didn't expect was a bunch of questions that required a lot of thought and have an hour to do them in."

Heather warned me in advance that her journal for the ninth week might be late. Her birthday was approaching and she was going with her family to the coast for the weekend to celebrate. When her week nine journal did arrive, Heather noted that she would only be writing one more journal entry and then the study would be over. "Just in case I forget to tell you this later, it was fun being a part of this project."

Heather had thought that her birthday would be "just another day" but some of her neighbors in the dorm got together and got a cake for Heather. Heather was surprised and thought it was "kind of cool." Heather was also happy to report that after some "very good hinting" to her parents she had received a guide to the Internet. "Now I won't bother you with my Internet questions anymore :)"

Heather reported in her ninth journal that she had failed the computer science midterm "like a lot of the people in the class." Heather said again, however, that she was

not going to worry about it and just work on doing well on the work that remained and "try to get a decent grade in the class."

Rick spent about 10 minutes in class one day during the ninth week explaining course requirements for the computer science major. Heather commented in her week nine journal, "It was nice of [the instructor] to explain why we have to take the classes we take. I had already known how important it was to take math classes but I wasn't as clear on physics but now it has come a little clearer for me."

Heather also commented that she had enjoyed the software engineering topic of the ninth week in the computer science class. "Last week's subject (software engineering) was what I was kind of looking forward to here this term. I guess it's because it's the kind of job that I'd like to do when I grow up."

When Heather wrote her journal for the tenth week the week to follow was finals week and classes had finished.

> I finished up my Residential Life Class for the term. Now, the next step in the process is applying for the job as an RA [resident assistant]. . . . I've decided to apply for the job and see if I get it. It could be a fun job as well as a good learning experience. . . . But somehow I have a feeling that I won't get the job. . . . I'm not a born leader but it would be fun to do. [Heather did get the job as Peer Advisor for the Women in Science and Engineering wing of the dorm for the 1994-95 school year.]
>
> CS was pretty good this week. It was neat not having class Wednesday or Friday. . . . I spent the free time putting comments in my program and playing games (good use of time, huh). . . . I finally showed up for a CS study session. . . . It was pretty good. It gave me another idea of what to study for. I don't think I want to completely trust the old test they handed out. I think I've learned my lesson.
>
> There's a study session for math this coming Monday afternoon. I'm planning on going to help out with the parts I'm not quite clear on.

In her week 10 journal Heather admitted that she had basically accepted the responsibility for supporting the computers in the dorm's resource room. "I think I've been appointed the job of taking care of the computers in the resource room. I guess it was one of those situations that once you [prove] you can do the job, you get it." Heather went on to describe the current state of affairs with the computers.

Heather and I had her final interview Wednesday of the first week of Spring term classes. Heather felt that the previous term had gone pretty well. "I think I've finally got into the college thing. [My study skills] I improved some, I could improve a lot more. I actually studied a lot more than I had Fall term which helped."

I asked Heather if she had enjoyed her classes. "I liked my RA class, my leadership class, so that was kind of the fun class of the term. And I actually understood what was happening in math this time around. CS went okay. It kind of wasn't what I expected initially but after I got into the class it became what I expected."

Early in the term Heather commented that her TA for the computer science course was easier to understand than her Fall term TA. "Yeah, he was a lot [more] confident of what was happening and not just sitting there reading his book [like the TA for CS 101]." Heather's only contact with the TA, however, was in recitation because she did all her work in her room rather than working in the CS lab or taking advantage of TA office hours in the lab.

I asked if helping Samantha affected Heather's work. "Well one time I didn't have my program done. I had it half done so I could help her as far as I'd gotten. She started asking questions on what I hadn't [finished] and I was like, let's see what would I do. . . . It kind of helped because then it kind of brought another point of view on the questions which sometimes is kind of hard to do yourself."

Heather enjoyed living in the dorm. When I asked her about it, she responded, "Yeah, I'm probably going to stay here for as long as they, [I] feel comfortable." Heather also talked some about her support role for the computers in the resource room. I asked her if she was bothered by the interruptions with questions. She said, "No, it gets me out of my room."

I asked Heather how she felt about her grades (CS 111: B, Residential Leadership: A, MA 202: C, and a C in her other baccalaureate core course). "I got what I anticipated at the end of the term. Math I got a C in which, it was okay. I did C work. I could have done better. I could have done better in [the physical education class] too but that was one of those classes that I didn't really care about. If I care about the class I'll do well in it. If I don't care about the class I'll just pass it."

At the start of the Winter term Heather had commented that her parents were surprised that she returned for another term. I asked Heather what kind of support she got from her parents. "Well, my dad's always interested in what I'm doing. And my mom just, I don't know, she [pause] just makes sure that I'm okay, don't need anything. I've made it clear to them that I am going to be in college until I graduate so [they believe me now]."

I asked Heather how it was now that her dad had e-mail. "It works, we talk. I mean, it's not major or anything but it's his way of not worrying having to try to call me and get a busy signal half the time [because of my computer modem use] or not get me."

When I asked Heather if she was still comfortable as a computer science major, she said she had given some thought to it. "I don't know, what else would I major in? There's nothing much else that I like other than, no, I was thinking, well, I could major in horticulture but I'll probably minor in that. I like plants and stuff. Going back to the Skills Center [during Spring break] where I spent like four years learning horticulture it's kind of like, woah, I haven't been around plants in awhile! But it's just one of those fun things to do." As for what aspects of computer science interested her, Heather was still interested in programming. "I still think, I still kind of think about being a software engineer. CS in general has come a little clearer but I still like the software engineering part of it."

As Winter term had come to a close Heather had asked about job possibilities and I had suggested a couple of places where she could look for information. I asked if she had been over to the computer science department to look for openings. "No, I don't wander around buildings very much but I'm subscribed to that newsgroup [the electronic newsgroup for computer science department news and jobs]."

I forgot to ask Heather the final question in the interview but sent it to her on e-mail instead. As a result I probably received a more thorough answer to my question about whether she felt her involvement in the research had affected her experiences.

> I don't think that being on this research has affected my experiences in the classes. I tried to keep the fact that I'd be sharing my experiences with my classes out of my mind until I sat down to write my journals. I believe that [you] answering all my questions over the few months didn't affect my experiences too much. I guess if I really needed an answer I could of

> looked harder in books or ask someone else with knowledge of that kind of stuff. I also don't think that it made me think of things differently either. I've heard a lot of other people's opinions on the classes. But unless I told you otherwise, I just gave you my thoughts on things.

Analysis of Heather's Experience

Heather's experiences in her first two terms as a college student and computer science major were shaped in large part by factors in three broad categories, (1) social interactions, (2) academics and university-related experiences, and (3) Heather's interest in computers and technology. Prior experiences with computing and interest in computers and technology led Heather to choose a computer science major. Then as Heather pursued her chosen major, her interests in computing were a major influence on her academic and social experiences in college.

Heather's interest in computers and technology was apparent from the first meeting and interview of this research. Technology surrounded Heather in her dorm room. When Heather talked about technology use, it was obvious that she enjoyed it. She was fascinated by computer software and technology. Heather's computing interest remained clear throughout the study and as the weeks of the study passed, a picture developed of how Heather's interest in computing permeated her social and academic experiences.

The support and encouragement of her father had fostered an interest in technology for Heather (and her brother). This common technological interest was an important bond between Heather and her father and Heather and her brother. The computer-related excuses for conversation were seemingly endless. Computer topics guaranteed that Heather talked regularly with her brother and always had something to talk about with her father. Heather's father was faithfully available with support, affirmation, and encouragement for Heather's career and academic pursuits. Her father's influence was a major factor in Heather's choice to enter college and pursue a computer science major. Heather's mother did not share the rest of her family's interest in technology and was more available to Heather for life support. In the final interview Heather also recognized these distinct lines of parental support.

As the terms passed and Heather's academic performance in her major courses was less than stellar, it seemed that Heather persisted with a computer science major because she did not know what other direction to turn. Heather was not driven by a strong career goal. In fact, with one exception, all of Heather's comments with regard to her college major and future career were prompted by my questions. Heather never felt like she knew much about a career in computer science. She appreciated any computer science career information she happened to receive but she did not make an effort to seek more information. Based on what she understood about computer science, Heather consistently expressed interest in a career that dealt in the programming aspects of the field. This preference clearly followed from Heather's experience with computer programming and her belief that a career should be personally enjoyable. Heather's experience with computer science per se was with computer programming and this experience had taught Heather that working with computers was fun.

Heather pursued her computer-related interests enthusiastically and she was always ready to give her time to anything associated with computers. Heather was immediately willing to be involved with this research and was most conscientious about her journal submissions to the point of struggling to make herself do homework rather than write to me. Involvement in the research exposed Heather to e-mail before her first day of classes as a college student. E-mail was a comfortable mode of communication for Heather and this computer-related diversion was a frequent distraction from her studies. E-mail and involvement in the research also supported Heather's interest in computing as she regularly turned to me for input on her computing questions. From her questions it was apparent that Heather invested many hours in exploration of computer software and resources available to her. Easy (and frequent) access to my expertise was, for Heather, a much appreciated benefit of research involvement.

Technical support was a major component of my e-mail conversation with Heather but Heather also called on me to answer a comparable volume of non-technical questions. Talk of life and small talk of the day surrounded all of the questions and answers, however, so Heather always kept me well-informed of her thoughts and activities. Heather was never as ready to talk in person as she was via e-mail. The interactive nature

of e-mail also allowed Heather to develop trust in me as my e-mail to Heather contained information about myself. This trust helped to extend the openness of Heather's sharing and communication with me. Heather used the e-mail system to keep tabs on me as she tracked my system sign ons and asked me to respond to questions about myself. The nature of e-mail communication and Heather's comfort and fascination with e-mail meant that e-mail was an excellent tool for gathering research data from Heather, data that would have been lost to any other means of data collection.

It was not easy for Heather to meet new people and new social situations. Whenever possible Heather chose to work in her room and use her computer rather than work in the computer science lab or do research at the library. The WISE dorm wing, however, provided a comfortable context for Heather to make social contacts. Most of the women living on the WISE wing with Heather were also first year college students. Heather's prior experience with and interest in computers allowed her to find her niche in the dorm as she made herself available to serve as the immediate computer support person for the wing. Common interests and classes as well as Heather's interest in computers helped initiate conversations and friendships for Heather with the other WISE students.

Heather greatly valued her friendships in the dorm. When she returned from Thanksgiving break, Heather observed that she really had no friends at home. Life and friendships in the dorm for Heather were preferred to life at home with her mom and dad. Heather's interest in dorm life led her to enroll in the residential leadership course in spite of the fact that Heather did not consider herself to be a "born leader." So in a few short weeks Heather moved from the social challenges as some of her biggest challenges of college to dorm social life and friendships as one of the major reasons for Heather to remain in college.

Social aspects of college life were a much higher priority for Heather's attentions than academic concerns. Heather never claimed it was her goal to achieve a 4.0 grade point average. Her goal for Fall term was to get an A in at least one course. Heather tended to do what she could do with regard to her course work and then spent little energy worrying about the outcome. Heather did not put pressure on herself to go beyond what was required and was inclined to give attention to work that held the greatest

interest as opposed to work with the greatest urgency. In keeping with this attitude a Fall grade report that was less than a 3.0 grade point average was "okay, good news." Her grades were what she expected from the work she had produced.

It took only five weeks for Heather to observe that too many distractions (e.g., television, computer) kept her from her studies. Distractions continued to affect Heather's study habits throughout the length of the study. In the second term, Heather put more pressure on herself to succeed and did improve her attention to study habits. Improved attention, however, only meant that Heather had better recognition of her study distractions. She never managed to generate much sustained focus on her studies.

Heather's most focused academic attentions were directed toward the work that carried the most interest for her, work related to computers and residential life. From Heather's indications it was work for CS 101 and CS 111 that was completed first and then the Fall term writing class (where Heather wrote a paper on a computer-related topic) or the Winter term residential life class received attention. In spite of the fact that MA 201 and MA 202, the discrete mathematics courses, were a part of Heather's computer science major, Heather did not devote the time required to these courses. The math courses highlighted the need for good study habits but did not hold enough interest for Heather to give time to them. Heather knew she was interested in computers but was unsure why she should be interested in mathematics.

Mathematics was not one of Heather's strengths but Heather knew enough about computer science that she prepared for college mathematics by completing an additional course in mathematics during the summer preceeding her first year in college. Heather's minimal contact with the University's computer science department, however, did nothing to improve the fact that Heather had little understanding of the field of computer science or the work that a computer science major was designed to support. Therefore, when Heather was faced with MA 201 and MA 202, difficult courses in the mathematics curriculum, her lack of motivation to focus her efforts on her mathematics courses reflected that she had little commitment to a computer science major. Computers were her interest.

Where mathematics was not a strength for Heather, her prior experience with computing served her well in her first two computer science courses, CS 101 and CS 111. CS 101 was easy for Heather because virtually none of the content of the course was new. This lack of new material might have made the course dull and slow for some students but Heather found the course to be of great interest. The content was computing. Heather did not mind the review and enjoyed the course.

Heather's prior computing experience also served her well in CS 111 where she found that much of the material was new. The new material and fast pace of the course meant that the course was somewhat difficult for Heather. Heather commented more than once that she was glad she had prior experience with programming. Heather became even more aware of the advantage of experience as she helped Samantha (who had no prior experience) with work in CS 111. In spite of the course difficulty, Heather remained interested in the material throughout the course.

Beyond her course contacts with professors and TAs, Heather's contacts with persons in the computer science department and other computer science majors were minimal. Heather's interest in a computer science major was supported by the University computer science department in as much as the department was involved in the creation and support of the Women in Science and Engineering dorm wing. Heather found support among the other women of the wing and the WISE programs helped open channels of information for Heather. Whereas the ACM meeting that Heather attended was male-dominated and socially intimidating, Heather was able to begin a dialogue with her mathematics professor at a WISE dinner. Presumably, Heather would not have initiated this one-on-one time with her professor without the WISE intervention.

Other university support of Heather's major was limited and this problem was made worse by the fact that Heather did not pursue people for answers to her questions or seek out information about her chosen field and major. Heather preferred to avoid advising sessions so she did little to take advantage of advising contacts with a professor in the department. While Heather possessed a keen interest in computers and computing none of her university experiences took advantage of her interest and drew her into the field of computer science or sealed her commitment to her major.

Samantha's Experience

Samantha was on campus a week before classes started. She had come early to participate in Rush Week, a week to make visits to university sororities before the decision was made to pledge to a particular sorority. Samantha attended the e-mail system training session Friday morning before classes started on Monday. After the training session we arranged a time Saturday morning for Samantha to come to my office for the first interview.

Early in the interview I asked Samantha to talk about how she became interested in computer science.

> The only thing I've ever really worked with is a Macintosh and that's not that hard. I haven't done anything like set up programs or anything like some of these people who are totally into it and stuff, not like that.
>
> I've always had a good feeling with computers and I've always been able to like, remember things that you're supposed to do. Where some people are just like, "What, I don't get it!" Like my mom is just like, "Forget it I'm not touching a computer because I hate them." . . . She's a people person more. I'm that way too but I like computers because you can do so much with them. . . .
>
> I want to go into graphics with it and maybe go into film because that "Jurassic Park" was all done with like graphics computers and all that stuff so that would be so much fun to just say, "I did that," to have an actual something to look at and say you did that not just be an accountant or something where there's nothing really to look at.
>
> I work on the Macintosh at home. My dad brought it home from NASA [where he is an aerospace engineer]. . . . I do all my papers and stuff on that and then I took a typing class in high school, WordPerfect 5.1, and did OK in that so I just always wanted to enhance my abilities. And if I don't like it there's so much other things you can do but hopefully I will because a lot of people don't stick with it and I'd like to.

I asked Samantha how she had learned what it meant to major in computer science.

> I read it in like the college [catalog] when I was picking my major. I read it and I wanted to get into computers and I read that and it sounded [like]

> there's more things you could do with computer science and go toward things that still had people involved. I don't want to just sit at a computer all day and just sit, I'm not like that. There's other things you can do, you can actually talk to people like if you have to set up a program, you have to talk to them and get it all ready. I liked that and computer engineering seemed a little bit too technical for me.
>
> My dad's pretty much the one who got me into it though because he's always around computers so he knows a lot more than I do. He told me what they can do because he's an aerospace engineer. I never thought I'd go into engineering. I'd be like, "No, I don't want to be like my dad." But, oh well.

Samantha briefly commented on her expectations for her Fall courses. "I'm not really into the major stuff yet, just Computer Science 101, and Elements of Discrete Math — I don't even know what that is but they said I have to take it in order to be in computers, I don't know, so okay."

Samantha talked some about her mathematics background.

> I went through pre-calculus [in high school] so I was expecting to take calculus this term. . . . I like math. . . . I think it's either you get it or you don't. And my dad's really good at math. He's so fun, because he's in engineering like, so, you ask him a question. You just want help with this problem. He'll tell you like the whole history behind it and you're just like, "No! I don't want to know this now!" But yeah, he's good at math so I guess that's where I got it.

At the University, freshman women cannot live in their sorority houses so Samantha lived in the dorm. She lived in the Women in Science and Engineering wing of the dorm and had a roommate who was a freshman in civil engineering. Samantha's high school boyfriend, a freshman business major, had come with her to the University.

Samantha was the only student in the study who did not have her own computer in her room. The resource room computers in the dorm were across the hall from Samantha, however, so it looked like Samantha would have fairly convenient e-mail access. I was further encouraged that e-mail contact with Samantha might work well because she had other persons with whom she might communicate via e-mail. Perhaps she could send e-mail to her dad and she also had a good friend who attended Berkeley.

Samantha had attempted to use the resource room computers Wednesday of the first week but had not successfully accessed e-mail. She had gone over to the library computer lab where she started a note to me that she did not send. In order to ensure that Samantha had convenient e-mail access, I made some phone calls to learn about the configuration of the resource room computers. I then arranged to go with Samantha to the resource room after CS 101 class on the first Friday to show her how to access the e-mail system from her local computers.

Samantha sent her first week's comments via e-mail shortly after I left her Friday morning. Her comments were brief and spoke only about CS 101. I was glad that I had the chance to hear some of her first week impressions as we walked to the dorm Friday morning. As for CS 101 she thought the instructor was "a little funny" [strange]. She felt that she would learn much more from hands-on experience in lab than she would learn from the class lectures. In lab they just "played with the Macs." Samantha thought her recitation TA was nervous in front of a group and did not talk loud enough. Samantha did not mention her math class and I failed to ask.

I could tell that Samantha had quickly met several women on her wing of the dorm. From the first day of class she came to CS 101 each day with another woman from her dorm. She had also met the other woman in the study, Heather. Samantha commented on our walk to the dorm on the first Friday that she thought Heather was either quiet or not very sociable. After I had shown Samantha and her roommate how to access e-mail from the resource room, they commented that there was another woman on the dorm wing who wanted e-mail access. I told Samantha and her roommate that e-mail accounts had been set up for all the women in the WISE wing. They told me that I was the first one to tell them this. Samantha and her roommate planned to tell others on the wing what they now knew about the wing's e-mail access.

Samantha signed on to the e-mail system once a day all of the second week of classes. The week passed, however, and I did not talk to Samantha either in person or via e-mail. Sunday, as the third week started, I sent Samantha an e-mail note and commented that I felt badly I had not talked to her all week. I told her I looked forward to her second week's comments and encouraged her to report on all of her week not only CS 101.

Samantha's commentary on the second week arrived Sunday night. She wrote a sentence or two about much of what was happening with her. Samantha thought the CS 101 lab quiz was "way too easy" and she felt fortunate that she had so much experience with the Macintosh computer and software.

After two weeks of classes Samantha was a bit frustrated with the discrete mathematics course. "I'm not too good at proofs because in high school the teacher would always skip over them. I'm doing better with them though. I can't believe I have to do them for two whole terms in a row."

Samantha had reached her friend at Berkeley via the Internet. They had used the UNIX talk utility to have an interactive conversation. "That is going to be a great and cheap way to hear the latest news from her."

During the third week Samantha signed on to the e-mail system twice a day. Thursday afternoon Samantha sent me some commentary on the week. She had received an A on her first assignment in her writing class so she was not as nervous about the next assignment that was due. She reported that her math class was "looking a little better" but she had not done very well on the most recent quiz. Samantha planned to do better on the remaining quizzes so she could discard the poor one. A week later I spoke to Samantha at her CS 101 recitation and she told me she had earned a 29 out of 30 points on her most recent math quiz.

With the fourth week Samantha's e-mail sign on pattern became once or twice a day. Tuesday I sent her a note that asked how things were going and asked Samantha to write about what special talents she was using. Samantha replied that she had been sick and had to miss two of her classes. "I hate missing things." As for my question about special talents, she felt that her talent in math was "being challenged" and she had yet to be asked to use her creativity.

After four weeks I questioned if my capture of information from Samantha was adequate. I wondered, since Samantha was a "people person," if conversation might work better than e-mail for her. Upon further evaluation of my data, however, I realized that my expectations were heightened by receipt of more information than I had expected from other students in the study. The information I received from Samantha was about what I

had expected as the study started. I sent a note to Samantha and asked if she preferred e-mail or conversation for exchange of some weekly information. She replied that she liked e-mail and would continue to write and would talk to me when our paths crossed.

Samantha usually took some notes during the CS 101 lectures although most students took no notes. In the fourth week Samantha and her female friend from the dorm started to regularly sit with a male student in class. This male student worked hard to maintain an image that stated he really did not need to be in class. In the fifth week I noticed that Samantha was less conscientious about her CS 101 note taking.

After five weeks of class Samantha's report on her discrete mathematics course was upbeat. "I guess I found out that if you do your homework when you're supposed to and check up on things you don't really understand as soon as possible, then you'll be okay. This has worked for me anyway. I got a B on my math midterm! Yea!"

At the end of the sixth week I sent Samantha a note that was returned to me undelivered because of a problem with her account. I called her on the telephone and helped her resolve the problem. Samantha's boyfriend had sent her a graphic image file that had consumed all of her allotted disk space. She was most appreciative that I could resolve her frustration with her inability to send or receive mail or delete the image file.

Samantha commented in her journal of the sixth week that she felt she had adjusted fairly well to college. "I'm having a great time with everything I'm involved in and I still have time to study. College definitely teaches you how to manage your time!"

Samantha reported that the WISE wing had a meeting during the sixth week where a representative from each engineering and science major was available to talk to students.

> It was great because I got to talk to a professor of CS about internships and scholarships that I might be able to apply for in my junior year. She also told me about some of the classes I'll be taking and what to expect. She said that if I want to do well, pick out someone who is older and doing well and do what they did. She was very helpful and now I have a better view of where I'm going and how to get there.

I knew that Samantha had met with her advisor during the sixth week and I asked her to comment on her advising experience.

> I knew that I had to meet with my advisor because they told us we would every term when I came to SOAP [Summer Orientation and Advising Program]. So I went to the CS main office and asked them how to set up an appointment and all I had to do was write my name in a schedule book. I found out the schedule of classes was available through my orientation class. So, I picked one up and with the help of that big, fat book that has all the information on what to take for your major, I made up my schedule. I didn't really get much out of [the meeting with my advisor] this time because all he did was sign my planned schedule card. When I was talking to [the professor at the WISE meeting] she said that they would get much better as I got farther into CS because there would be more opportunities heading my way. That sounds acceptable!

At the point of the seventh week it seemed that Samantha would tell me most anything but I might have to ask to get the information. While I felt that Samantha gave me good information, I was concerned that Samantha might become dependent on my questions when what was really needed from her was some indication of what she felt was important. I sent Samantha a note that explained again how an important facet of the research was to have students identify topics of significance for them.

In the eighth week I asked Samantha how she spent her time when she was not studying. "When I'm not studying I usually manage my time around my sorority activities, Student Alumni Association (which I recently got into), other various clubs, and spending time with my boyfriend. It's not easy sometimes but I've been managing pretty well."

There had been a recent discussion in CS 101 about the difficulty of the midterm exam. Samantha wrote some of her reactions to the discussion. "I don't understand how people can think that class is hard. If you've never used a Mac before I can see why it would be a little challenging, but I'd never call it hard. I think a lot of it is just an excuse. On the midterm I got a 94% because I studied for it. Sometimes I wonder if these people are really studying. As the courses go on I expect them to get much harder so I'm glad I don't find this class hard."

In the ninth week, the day before Thanksgiving, Samantha arrived in class with her completed term project. The deadline had been extended to Monday but Samantha went to California for Thanksgiving with her family and was not able to be in class on the

Monday after Thanksgiving. On the Wednesday before Thanksgiving Samantha seemed anxious to leave on vacation. She and her friends seemed particularly impatient or annoyed with Aaron's disorganized demonstration of Mosaic and his obvious enthusiasm for computers.

I spoke briefly to Samantha at her Tuesday recitation during the tenth week of classes. She told me that the resource room computers were not working so she had to go to the library for e-mail access. At the end of the tenth week Samantha wrote, "It's working out okay to come to the library, except for e-mail. I don't like having to come over here to just get my messages. It's kind of a pain and I can't keep up as well. It was definitely better when the computer was right down the hall." When Samantha reported her displeasure with the computer situation, I made some contacts with the technical support persons for the WISE equipment. The computers were working by the second week of the Winter term but access to the e-mail system was unavailable until the end of the eighth week of the second term.

While I was at recitations during the tenth week of Fall term, I checked the CS 101 grade sheet posted in the lab. Samantha had a 96% for the course and had not completed any bonus projects. She reported in a note during finals week that she had received 100 points out of 100 possible on her CS 101 term project where she had chosen to do a Hypercard project rather than write a term paper. "I was very happy. I spent a lot of time on it, mostly because I did a term stack and I'd never used Hypercard before. It was fun to learn something new though."

Samantha earned A grades in all her courses for Fall term (CS 101 and baccalaureate core courses) except for a B in the discrete math course. In the second interview Samantha commented that, "My grades were very good for this term. I'm just hoping I can keep it up because my parents are like expecting things now. . . . My dad was like, woah! He couldn't believe [my good grades] because he just bombed his first term [at MIT] because he had it so easy in high school."

I asked Samantha in the second interview to reflect on her experience in the discrete mathematics course.

> It was kind of difficult but then I guess it was just because I wasn't used to that kind of stuff and then if you get into it and you go to every class and you try to do it and you get the answers back for the homework and stuff then it's OK because you know what you've done wrong and stuff. And I guess people who had real problems could always talk to the instructor. She was really nice. I thought she was a great instructor. I liked her a lot. . . .
>
> The exams are pretty hard. They always throw one in there that you're like, woah. . . . I did alright, I got a B in there so I was happy. I was very happy.

I commented that Samantha seemed to have good time management skills.

> I've been very happy that I've found out how to do that. I think it's probably because of high school, band was like [a] major time commitment. . . . They'd always call practices on us. We didn't even know they were going to happen and then they'd get all mad at you if you couldn't show up and I also had to work so I guess that helped me a lot. I knew how to manage my time real well or make it work.

I asked Samantha to talk about how she felt about her choice of a computer science major after one term of college.

> I think I like my major pretty much so far. I mean I'm not into the nitty gritty of the stuff but I think I like it. I was talking to a lady back home and she said if you had a degree now I would hire you in a second, because that's a great field — a lot of demand. . . . I don't have really a real strong idea of where I'm going because there's so many things you can do. I kind of want to be part of inventing the future. . . . I think that would be a lot of fun to be a part of that. I don't know about the graphics now because I've heard that's a lot of math and I just don't know if I want to do that for the rest of my life. It just seems kind of boring. . . . I don't really know where I'm going but I know I like it. I like working with computers.

As she talked about how she felt about her major, Samantha also spoke about her reaction to CS 101.

> CS 101 was kind of boring because I already knew how to use a Mac and I really didn't like the instructor at all. He was just not good. He was just so annoying! Because my friend that I always sat with, she was on my floor, that one day when he was trying to get the VCR to work and he goes, "I don't see any sound coming out." We both just kind of looked at each other and went, "Oh, my gosh." And then the other day when he asked if anybody had technical competence I was like, "Oh my gosh. I can't believe you are a computer science major." He was just too funny but hopefully it will get better.
>
> I learned a lot in that class. . . . I learned a lot about the history of computers and all that stuff and more things to do on the computer, on the Macintosh, other than just writing papers. So that was good but my major annoyance was the instructor.

Samantha was looking forward to CS 111 Winter term with Rick as the instructor. "I know I'll like this guy that's teaching now because he was my advisor [for SOAP]. He's really nice. So, I think he'll be good. Seems like a real nice guy, he cares. He was here for SOAP. I thought he was my advisor but now I have a new advisor."

As the interview ended, I thanked Samantha again for her willing participation and contribution to the study. She thought it was "neat" to be involved and did not feel that it was too big of a commitment.

> I enjoy talking to you because you've had experience in all this stuff and I can ask you questions if I have them and it's nice to know that there's someone there that knows what you're going through. Because you tell your parents about how hard it is and they might not believe you. . . . It's just a lot better. You can talk to your friends but they just don't understand. They know it's hard but it's just conversation. But you understand. It's really nice to be able to talk to someone who's been through it.

I received Samantha's first e-mail journal of the new term after more than two weeks had passed. For two weeks the computers in the resource room of the dorm were not working but Samantha still signed on to the system at least once a day. Samantha had gone on a weekend ski trip the second weekend of the term so she was busy trying to stay on top of school work. Samantha sent her first journal the day that Rick covered a class example of a problem quite similar to the second programming assignment. "I just

finished my project for CS 111. I got a lot of hints from today's lecture. I pretty much just remodeled my first [idea] though. I'm happy that I at least had the right idea. I'm scared for the next one though. I've never programmed anything before so this is definitely all new to me. Much better than CS 101."

Samantha's second journal of the term arrived Sunday at the beginning of the fourth week. She was excited to be finished with the third assignment for CS 111 that was not due until Thursday. "I feel really good because I just finished my CS assignment and guess what? It works! Yeah! It's weird to know that I can actually make a computer do something."

After four weeks Samantha's comments sounded positive. Samantha said the discrete math course was making sense. "Maybe it's because I have some background and I am used to it? Who knows but I'm happy about it." Samantha was also enjoying the computer science class. "I enjoy the assignments most of the time but I haven't started on this week's yet."

Samantha sent a quick note at the end of the fifth week. She said the week had been busy but she was happy to report a B on her math midterm and 100 percent on her CS 111 midterm. Samantha's busy week also included time spent on completion of the fourth assignment in CS 111. At Samantha and Heather's CS 111 recitation Thursday I noticed that Heather asked Samantha if she had finished her program. I assumed that Samantha may have gone to Heather for some help on the assignment.

Samantha missed class Friday of the fifth week and I noted that it seemed a particularly bad class session to miss. Rick handed out the description of assignment five, reviewed control structures (the material covered quickly all in one recitation), and covered new C++ material necessary to complete assignment five.

A note from Samantha on Saturday of the fifth week indicated that although the new computers had been in the resource room for three weeks, there was still no e-mail access for her in this most convenient location. She used her boyfriend's new computer to do some of her work and was in the computer science lab to complete her CS 111 assignments. Samantha said computer access was not a problem but I did hear more from her in Fall term when she had e-mail access across the hall from her room.

Samantha's note at the end of the sixth week again sounded as if she had all she could handle to keep up with her school work. She was glad the week was almost over and she had, somehow, managed to get everything done. I wondered whether shorter notes to me were just part of necessary time management for Samantha. She wrote without reminders from me but notes were short and not filled with information.

After I received Samantha's sixth week note I sent her a prompt to write about CS 111. I wrote: "Can you offer any commentary on the week in CS 111? There's been an assignment due that obviously enough people were having trouble with to extend the deadline, there's been a guest lecture [by Kyra on recursion], and the new programming assignment incorporates a number of new elements and concepts." Samantha had just learned about an unexpected opportunity to make a weekend trip home to California so my prompt failed to get much of a response. Perhaps Samantha's response just meant that she took everything in stride. "Well, the last assignment in CS wasn't too confusing. . . . Assignment 6 is a little more confusing for me. We have [another week] to turn it in though so I still have quite a bit of time."

Samantha missed two days of class because of her weekend trip home. She said, however, that it was not too hard to catch up on her school work. Samantha sent me a quick note on the eighth Wednesday after she had completed assignment six which was due the next day. She felt quite relieved that the assignment was finished and said the assignment was really confusing for her. Samantha mentioned that she was headed to the midterm review for CS 111 that evening. "I'm really glad he offers those because it's hard to tell what's going to be on [the exams] sometimes." After she went to the session she wrote that it had been very helpful. "Now I know exactly what to study." Friday, Samantha worked on the midterm until time was called and she was required to submit her exam.

At the end of the eighth week, the WISE resource room computers finally were equipped for e-mail access again. Samantha signed on once or twice a day. I did not hear from Samantha, however, all of the ninth week until Sunday night. She wrote from the computer science lab while she worked on the final CS 111 assignment. "Well, I did pretty bad on that CS test. I know I'm not alone though. I'm mad because I had 100% in

that class and now, even if I ace the final and my next project, I still can't get an A. I'm wondering if I should go and talk to [Rick] about it? It just seems so unfair. What do you think? Well, I'm having trouble with the assignment we have now [assignment seven]. It's really confusing. I'm certainly glad the quarter is almost over." I replied to Samantha that I thought Rick would like to talk to her about the midterm. I told her he would probably also be interested in why she felt she did so poorly on the midterm when she had done so well on everything else.

Saturday of the weekend before finals, Samantha wrote that she still planned to talk to Rick but had not done so yet. She was "kind of scared" for the CS 111 final because of the second midterm results but planned to study hard and do well. Rick did not assign pluses or minuses with grades but Samantha finished with a B in CS 111, a B+ in MA 202, and As in her baccalaureate core courses for the term.

The final interview with Samantha occurred during the first week of Spring term classes. She started the interview with talk about what she had enjoyed in Winter term. She enjoyed programming and felt good that she could find people to help her when she needed help. Samantha commented that Heather had been a big help to her since Samantha had never programmed before. Samantha had never had a problem with computer access in the lab and enjoyed working in the lab because other people were there to answer questions.

> I enjoyed the programming. I thought that was kind of fun. I've never done it before, ever, on anything. So I was like, okay, am I going to be able to do this? But it turned out that I could do it. I think one of my problems is that I don't really understand like the algorithms yet. But I guess that comes with time. Because I was too wrapped up in getting the code all ready [syntax].
>
> I liked the idea that I could talk to [Heather] and stuff like that if I got confused. There were people around to help me and there was usually, when I went in the computer lab, [Rick] was either there or a TA was usually there so that was good. They were usually very open to helping me and stuff like that.

Samantha had quite a bit to say about how she had not liked the second midterm and the fact that her score on the second midterm had prevented her from earning an A in the course.

> I thought the tests were pretty good except for the second midterm. I think I did well on the final. . . . I ended up getting a B in the class and I'm not happy about that because I had a 100 percent before that midterm. I mean even on my other midterm I was like, woah, I can't believe I did that well. I never got 100% on anything before, like a midterm or anything and so I was happy about that. . . . He [Rick] said, it was kind of weird though, because I asked him about it and he goes, "Well if there's only one thing that's pulling you down then we usually give you a higher grade." Well, I guess not. . . . It was probably because it maybe wasn't on the borderline or something. I don't know why but it's over now.

The second midterm asked students to read and write code and tested their understanding of algorithmic logic. I asked Samantha to talk about what she had expected on the second midterm. "He [Rick] didn't spend very much [time on algorithms] in the review session thing. . . . So I was like, woah! And I didn't think we had gone over it that much in class in order for it to have that much on the test about it."

Samantha had just commented that she was still not comfortable with the logic of algorithms so I asked her how she felt she would do on the second midterm if she were to take it at the current time. "I probably would do better now that I know what was expected because I didn't really understand some of the questions. . . . There were some that I wouldn't have got, I wouldn't probably do much better on like the recursion. That's still really, I don't understand that."

Throughout the term Samantha had not said much about the discrete mathematics course. I asked her how she felt it had gone.

> It was a lot better than [the Fall term discrete math course] I thought. I thought it was easier to understand. It was more stuff that I'd heard before I guess [in high school math classes]. Just like the graph theory and stuff was really easy to grasp. Because I like geometry and I like stuff like that so I can see, okay, yeah, I understand that and I can pick that up pretty easy. . . . Math I kind of enjoyed. Because I really like her, my teacher

> [the same professor as Samantha had for MA 201]. She's really good. I like her.

At the time of the third interview Samantha was still comfortable with her choice of a computer science major. "I thought that I might change it or something but no, I'm not thinking about changing it at all yet! I'm really enjoying learning because it's all stuff that I haven't done before and I think that's what I like about it. It's not boring to me. You know, and I have people around me to help me and I don't get too frustrated. . . . I really like it so far."

Samantha talked about the support she received from her father. He was a wonderful source of encouragement for her. "He's never programmed either, never. I told him that I was doing programs in C++. 'What? You are? Wow! That's cool!' So he's kind of surprised about that. But if I ever have any troubles with calculus I know he'll remember everything he learned. Because he always, he's so funny. He can tell me anything. So he'll help in that aspect."

I asked Samantha if she felt she had good access to information on internships and career opportunities. She thought there was good information available and it sounded like Samantha made an effort to seek out such information. She read what was posted on bulletin boards in the department and faithfully picked up and read the departmental newsletter. Samantha found the campus career center to be a big help and she said she went there quite often to check updated listings. "I know a lot of people that are juniors and don't even know how to do it [use the career center]. I'm just like, what's your problem? You've got to start early you know!"

Samantha talked some about the career she could picture for herself in computer science.

> I don't think I want to do programming for the rest of my life. That just doesn't sound very fun. . . . I don't want to just be one lonely person doing one thing because it's just, I like to interact with people and get their ideas and stuff. I think it works better that way. Takes more time but works better. . . . I kind of want to go into the area where maybe new things are being developed, like new ideas and futuristic things because I think that would be a lot of fun. . . . I think I'll probably take a graphics course

> sometime whether I want to or not and then I'll probably get an idea but I don't know yet. I'm not real sure but I'm pretty sure there's many things that will pop up that I'm interested in.

As Samantha's involvement in the study ended with the third interview, I asked her to reflect on how her involvement with the study might have influenced her experiences.

> I think that it kind of helped in some ways because I had someone that I could talk to like you. I could tell you what was, and I knew that if you said something about it or if you wrote about it or whatever it might change for the better or for the worse, or you know, do something in that aspect and I liked that idea. I think it probably made me work a little bit harder because I wanted to show you that I could do this. I have someone kind of looking over my shoulder and that always kind of helps along because you don't want to like disappoint someone or you know something like that. And I think that helped in the aspect.
>
> I really liked being able to write you and tell you what's going on and share my experiences with somebody who had actually been through it you know. Because if I told [Heather] or something, she's going through it too so it's not that big of a deal or anything and it doesn't really mean anything. And if I tell somebody else they don't know what the heck I'm talking about. So I liked that because I could actually maybe get my frustrations out or just tell you something. I'd feel like it actually meant something.

Analysis of Samantha's Experience

The major factors that impacted Samantha's first two terms of experience as a college student and computer science major were her interests in people and relationships and her positive attitude about school and learning. Samantha characterized herself as a people person in the first interview. The importance of people and relationships for Samantha was reflected in nearly all of her decisions and experiences for the period of her research involvement. The other theme in Samantha's academic experiences was the fact that she enjoyed learning.

Samantha knew what it took to be successful in school and she capably and conscientiously pursued her school work. Samantha made few comments about her

courses other than mathematics and computer science. For her other courses, she capably did the work required and assumed that the "normal" experience of satisfying course requirements was of little interest to the research. Good grades were important to Samantha and she was willing to do the work that was necessary. She had little sympathy for other students who complained about the difficulty of courses while apparently they expended little effort toward completion of the work required by the course. Samantha commited considerable time to her studies, an expectation that did not come as a surprise to her. Samantha knew that good time management skills were important and she was proud of the fact that she was able to successfully balance her studies with her social commitments.

Samantha not only knew what it took to be successful in school, she liked school. She enjoyed learning and had little patience for classes that wasted her time by not teaching her anything new. CS 101 was a problem for Samantha because she wanted to learn but the content presented was either simple or material she was confident she knew. In the last part of the term Samantha looked bored and exhibited less patience with the instructor. The bright spot in the CS 101 term for Samantha was her term project. Samantha made a deliberate choice to write her project in Hypercard so that she could learn and work with software previously unfamiliar to her. She was proud of what she had produced.

Consistent with her joy in learning, Samantha was happy when the second term of discrete mathematics made sense to her. She enjoyed this difficult mathematics course. Samantha thought CS 111 was a much better course than CS 101 because the content was all new to her. She was excited when her programming assignments ran successfully. In spite of the hours of frustration, Samantha reported that she enjoyed the assignments in CS 111.

Samantha credited her father as a major influence in her involvement in computer science. Samantha's engineer father was incredibly supportive and affirming of Samantha. He took a sincere interest in Samantha's school work. While Samantha's mother was supportive as well, it was Samantha's father who took an interest in the content of Samantha's work. At times Samantha chuckled at her father and cast him into the model

of a stereotypical engineer but Samantha genuinely liked her father. Samantha saw her involvement in computer science as "being like her dad" but she had resigned herself to the fact that the similarity was not all bad.

Information from her father was in large part the basis for Samantha's image of computer science and a computer science career. Her father's information combined with her prior computing experience set Samantha's focus on computer applications. Computer science interested Samantha because computers could be used in so many ways. While people who were "totally into it" wrote programs, Samantha wanted to enhance her abilities to use the computer as a tool.

All of Samantha's talk of a computer science career came in response to some prompt from me. Samantha independently sought out information about careers and internship options but she was more interested in a summer job than clarification of her future career options. For Samantha computer science happened when work was done with a computer. Over the course of two school terms this view changed little in light of whatever information she gathered. Samantha enjoyed work with computers and computer work was part of the appeal of a career in computer science. It was also important to Samantha that her career involve work with people. She felt that a computer science career could be people-oriented. Finally, much as Samantha took pride in her academic work, Samantha saw computer science as a career where pride could be taken in the product produced.

Samanatha entered the University confident that she could do well academically. This confidence in regard to computer science was expressed as her "good feeling with computers" and was a part of her decision to pursue a computer science major. Samantha's confidence in her academic abilities extended to mathematics. She liked mathematics and felt she did well in mathematics. The discrete mathematics courses were difficult courses but Samantha's good study habits brought her success in spite of initial difficulties.

Most of the difficulty for students in the discrete mathematics courses came from the emphasis on mathematical proofs. Samantha had good high school mathematics preparation but she reported what is a typical experience in high school mathematics

classes. Her high school mathematics teachers always skipped the proofs. So, as Samantha entered college, her mathematics preparation was good but she had little experience with construction of mathematical proof.

Samantha's success in discrete mathematics, which she entered with little experience in mathematical proof, was a contrast of interest in comparison to her experience in CS 111, which she entered with no prior experience in computer programming. In discrete math Samantha found that when she did her homework and asked questions she came to understand the course content and mathematical proofs. In CS 111 programming was treated as a side issue and no instructional time was given to help students develop an understanding of programming logic. At the end of the course Samantha recognized that her focus in completion of programming assignments was on syntax and she finished the course with little understanding of programming logic. Samantha questioned her ability to succeed in future programming courses which treated CS 111 as a programming experience prerequisite.

Samantha was always true to her personal assessment of herself as a "people person." From sorority activities to a shared, rather than private, dorm room to her academic strategies, Samantha consistently put herself with other people. One of Samantha's strategies for academic success was to seek out other persons who could help her. Samantha felt good about CS 111 because she was always able to find someone to help her with programming assignments. Samantha's review of courses never failed to include an assessment of how she felt about the instructor. It was important to like the instructor.

Samantha appreciated the contacts she had with people as a consequence of residence on the WISE dorm wing. Other wing residents were available for course help and understanding friendship and support. Since Samantha did not feel that she received much input from her advisor in the computer science department, Samantha appreciated the opportunities for conversation and exchange of information at special meetings arranged by the WISE wing.

Samantha's involvement in this research was another important contact with people for Samantha. While I provided some e-mail, computer hardware, and other technical

support for Samantha, what was important to Samantha was that there was someone who was interested in her and understood the realities of her academic experiences. Samantha felt that in the support and knowledge that someone cared and was watching, she pushed herself a little harder to succeed. Where other students had started as computer science majors and then changed, Samantha wanted to be one of those students who stuck with it and she hoped her input via the research would produce change in the system.

At times I felt that Samantha thought of me as a mentor and was a bit disappointed. Because of my role as researcher, I was not as free with information as I would have been if I was in a mentor role for Samantha. We talked fairly infrequently and Samantha did not get to know me well personally. Our somewhat distant relationship was another disappointment to Samantha, someone who enjoyed her contacts with other people.

Trent's Experience

Trent lived in a university dormitory but was on campus a few days before classes started in the Fall. He wanted time to set up his computer and settle into his room. Trent had a roommate in the dorm, someone he did not known previously, and his high school girlfriend was a freshman in the theatre department at the University. Trent attended the e-mail training session on Friday morning before the first week of classes. I met for the first interview with Trent immediately after the e-mail session.

I asked Trent to talk about how he became interested in computers.

> Well actually it started fairly recently. . . . I've always been good with higher level math. . . . I didn't do so well with geometry but then [in] Algebra II and Elementary Analysis I did really well with the problem solving and the logic involved with that. I really didn't know a whole lot about computers but it seemed to me that that would be a career where my skills with problem solving — it would be a good place to apply that. So, as it is the only experience that I have really with computers is that I took a Pascal class my senior year. It was a basic introduction to Pascal on a Macintosh. That got me going. I kind of had a slow start [because I had not used computers before] but after the first quarter I was really getting

> into it. I was really — I wasn't as fluid with it as a lot of people around me were that had been there for a couple of years but I really, I felt a connection like there was a definite possibility that if I spent some time, I could go places with this computer business.

Trent said he enjoyed the challenge of solving problems on his own.

> It's enjoyable to me to work through the process to get the answer, to go through however long it takes, hours of working through the equations and then finally getting the solution. That's always a definite sense of satisfaction to go through that process. I like doing that.

Trent talked some about his choice of a computer science major and his vision of the future.

> I was kind of looking towards taking some business classes maybe even a minor in business and if I get really ambitious maybe even a dual major but that's a ways down the road so I won't make any projections as to what that will be but I'm thinking about possibly incorporating business skills with a computer science degree — maybe consulting or possibly helping companies set up networks or problem solving or what have you. I'm really vague in what this will accomplish at this point but I'm hoping that as the years progress I'll have more information and be able to make some more informed decisions.
>
> Another thing that's appealing to me is the fact there appears to be quite a future in it — not this insecurity that a lot of careers are having right now. Definitely see that computers are integrating into the world more and more and I see it as an opportunity to, at this point and time, be able to get on that and get going with it and be a major player in the future.

The main reason for Trent's choice to attend the University was that it was the school he could afford financially. He also talked some about his educational goals.

> I'm kind of looking to possibly transferring in a couple of years if things go according to plan. Looking towards the business side of the long term goal, I'm kind of looking possibly even towards New York. . . . I liked the fact that [at the University] there were many, many options, that I wouldn't be trapped into just studying a few specified things but I had the

> opportunity if I want I could take a theatre class, and I could take business classes and there's a large variety of different classes and opportunities and that really appealed to me also.

Other than his time on campus for SOAP and brief visits with me, Trent said he had no contact with people on campus. What he knew of his Fall classes he had learned from the university catalog and the texts he had purchased for the courses.

> The one thing that I really had no idea what I was getting into was the math class — the computer science math class. . . . I kind of got the feeling that maybe it was, it would seem logical that it would be some sort of what we did in [high school] elementary analysis. . . . When I looked at the book it turns out that's what it is, so I feel a little less insecure now that I have some sort of an idea as to what it's going to be.

Trent said he was pretty confident that he would do fine in his classes. "Nothing too stressful, all things that I'm fairly familiar with and I'll be able to deal with."

Once the interview was finished I walked over to the dorm with Trent to help him set up the communications software on his computer. I spent about an hour with Trent and he was most appreciative of my help. Trent had not had his computer long but he caught on quickly to what I did. His ability to make sense of my help seemed to bolster his confidence. In the first week he had trouble with the program I had installed but found another program on his machine and successfully made it work.

Trent wanted to be involved in the study because he saw it as a way to help someone. My impressions after my initial time with Trent were that he was laid back [unhurried] and introspective but enjoyed his visit with me.

Trent usually arrived at least 10 minutes early for class and sat toward the front of the classroom. After about two and a half weeks I realized that I could often catch Trent waiting in the hall before class and he was happy to talk to me. Throughout Fall term, Trent signed on to the e-mail system about once a day but face to face conversation worked better than e-mail as a way for me to keep in touch with him. Conversation was, however, often focused on topics not directly related to the research.

In the first week I spoke briefly to Trent once after class and again at his recitation. When I had not yet received any written comments from Trent on the second Monday afternoon, I sent a reminder for him to use e-mail to send some comments about his first week. He sent a short note to say that he had not written because "nothing very exciting happened to me." He was getting settled and classes were going well.

A note sent on the second Wednesday indicated that classes were going well for Trent. He particularly enjoyed his philosophy class. Trent had a work study job on campus that kept him busy 13 hours a week but he seemed to be on top of his studies. Trent's job was in the campus media center but the job left him plenty of on the job time for his studies.

Class on Monday of the third week was a demonstration of the word processing program that Trent used on his own computer. When Aaron gave the opportunity for those students comfortable with the program to leave, Trent left. By the third week I had observed that Trent rarely took notes in CS 101. In his note in the third week Trent commented that CS 101 was "going painfully slow. The reading is fairly interesting but those labs are hardly worth going to." Trent said he looked forward to his philosophy and discrete math classes each day and found both "very challenging."

I had prompted Trent each week to send his comments and in the third week he apologized that he was inconsistent in sending them. He said he was still trying to budget his time and at times he lost track of less pressing items.

Trent's fourth week note reported that he was busy in preparation for the midterms in CS 101 and discrete math later in the week. He said he felt fairly confident about both of them. Trent also responded to my question about which of his special abilities he was asked to apply in his college experience. "My math class is working my logic skills and my philosophy class is giving the inquisitive part of my mind a good work out."

I talked to Trent before class on Wednesday and Friday of the fifth week. He had done quite well on the CS 101 midterm but was not specific about the discrete math midterm. He only said "it was salvagable." He felt he had not put enough time into preparation for the math exam but had learned what to do to prepare for the next one.

Trent also told me that he really enjoyed his philosophy class and had received perfect scores on a number of papers.

At the end of the fifth week Trent had an appointment with his math professor to discuss induction proofs. After the visit with his professor he felt he understood induction proofs and they were "easy." He commented that now he needed to work on proofs that involved sets. It would take time but he felt he had plenty of time. He said he just needed to work on using his time wisely.

When I talked to Trent in the sixth week we discussed the hacker attack on the computer science department machines. Trent questioned what would motivate someone to such vandalism. Trent also said he had avoided use of the e-mail system because he did not want anything to happen to his personal computer. I assured him that the hacker attack did not affect his e-mail system and also explained that his personal computer could not be affected.

In the sixth and seventh weeks I continued to send Trent notes of encouragement to use e-mail to send me comments. Trent did not write but our paths crossed frequently enough and he always wanted to talk. When I talked to him in the seventh week he was headed to another appointment with his math professor. There would soon be another midterm in discrete math. Trent said he understood the content; he just hoped that his math professor could give him some tips on how to speed up the process of writing a proof. In spite of his first midterm results, Trent still hoped to get a B in the math course by doing well on the upcoming exam. When I saw Trent at the end of the seventh week he was anxious and happy to tell me that he had earned a B on the math midterm.

Trent was confident as he waited to enter the classroom to take the second CS 101 exam. He commented that he was a bit puzzled by discussion in class which indicated that the second exam would be easier than the first exam. Trent thought the first exam was pretty easy.

When I talked to Trent on Monday of the eighth week he asked me how he should make contact with his advisor. I explained that he needed to go to the computer science department office and sign up for a time.

Following our conversation on the eighth Monday, I next heard from Trent when he sent me an e-mail note on Saturday of the eighth week. He said he noticed that we had not talked in awhile so he had been planning to write. He wanted to tell me that he had decided to change his major to business administration with computer science as a minor. I sent him a reply that said I would want to talk to him sometime about the factors influencing his decision. Two and a half weeks later, during finals week, we talked for 35 minutes about what had led him to change his major.

Trent told me that one of the reasons he had changed his major was because he did not want the career of a computer scientist. He had talked to his uncle who was a programmer. Trent did not think he wanted to "sit at a computer writing programs for 15 hours a day." For his CS 101 term project Trent had read a book on hackers. He found the book to be interesting and thought provoking. He also got the idea from reading the book on hackers (and from a video shown in CS 101) that successful computer scientists were obsessed with what they did. Trent did not feel that he had the drive to be an excellent computer scientist.

Trent said that he still thought of himself as a computer scientist. His goal was to become adept in the use of computers so that he could use computers as a tool in some kind of business management position. He realized that he liked work with people and enjoyed the responsibility of leadership. The computer would support his management work.

Trent commented that picking a major as a freshman was really a shot in the dark. He felt it was hard to have enough information on which to base such a decision. He saw that even his choice of a business concentration might change as he took more classes.

Trent talked, in our finals week conversation, about classes that interested him. He wanted to take Greek history, advanced physics, and in order to support his physics, more math courses than a business major required. He also reiterated that he enjoyed solving problems. Trent recognized, however, that he had to be careful because he had a tendency to overextend himself in pursuit of all his interests.

Trent looked forward to "getting a fresh start" with mathematics courses. He was starting the calculus sequence Winter term. Trent had taken his senior year of high school

math by independent study because of a scheduling conflict. He felt that consequently his math study skills were rusty at the start of Fall term. Trent saw that his less than adequate study skills had allowed him to get behind in MA 201 at the start of the term. Then he was always playing catch up throughout the remainder of the discrete math course.

I also learned during our finals week conversation that in Trent's regular sign ons to the e-mail system he sent mail to an aunt and two friends enrolled at distant technical universities. Trent said that at first he did not see why people got so excited about e-mail but now he thought that it was "pretty neat."

I explained to Trent that even though he had switched his major I still wanted to follow him in the same manner through Winter term. Trent would be enrolled in CS 111 Winter term and the only difference was that he would have calculus instead of the second quarter of discrete math. I told him I thought it would be an interesting contrast.

On Wednesday of the ninth week Trent sent me an e-mail note that asked what he should do about enrollment in CS 111 because the course was full. I made some inquiries and discovered that other students also had this problem. To alleviate the problem the computer science department had adjusted the arbitrary enrollment limit. Trent was relieved when I called him and told him the problem was resolved and he should try to complete enrollment again.

I talked to Trent before class on Wednesday of the ninth week. It was the first time he had mentioned his parents. His dad was coming down to pick him up for the Thanksgiving weekend. Trent also mentioned his mom as he explained that he had been unable to enroll because he needed to clear up his immunization records.

I called Trent at his parent's home over the holiday break to arrange a time for the second interview. I happened to talk briefly to his mother during one phone call. She said that Trent had been interested in business since eighth grade. His eighth grade English teacher thought he was the only eighth grader who read the business section of the newspaper to pass time before class.

The second interview with Trent took place the day before classes started for Winter term. Trent received an A in CS 101, a C in discrete math, and As in each of his baccalaureate core courses Fall term. With the exception of the math course, Trent felt

good about how Fall term had gone. Trent started the interview with some reflections on his study skills and his experience in the discrete mathematics course.

> It seemed to me that the material in the class wasn't nearly as hard as I made it. The hardness came about from the fact that I wasn't a college student yet. I was still a high school student. In high school all you have to do to succeed is come to class. I don't think I ever spent more than 10 minutes, if that, a night doing homework and came out of high school with a cummulative 3.6 GPA. That doesn't work in college. I saw the fact that I wasn't putting nearly as much time into studying as I needed to and when I finally figured out what it was that I needed to do, it was too late. . . . I'm hoping that I'll do considerably better in my next math class [calculus] coming up.

Trent clarified that avoidance of the second discrete mathematics course was not a factor in his change of major. He felt he could do well in mathematics and wanted to prove himself. Trent said if he had not changed his major he would have retaken the first discrete math course so he could have done well in the second discrete math course.

Trent commented in our conversation during Fall term finals week that while CS 101 had been easy, he was glad he had taken it. He felt that it helped fill in some of the gaps in his knowledge. I asked Trent in the second interview to reflect on his experience in the CS 101 course.

> I did just fine in the computer class because it was still a high school level situation so I didn't need to do any homework in it and I did just fine. It's probably not the most challenging thing in the world but it was kind of a buffer between [high school and college]. . . . That was more of an introduction to Microsoft Works than an introduction to computer science. . . . As far as computer science people are concerned, if they've chosen computer science as their degree of choice then chances are that they've probably used a computer before and the CS 101 class probably isn't necessary.

Trent said that as he looked ahead to Winter term he looked forward to calculus and the computer science course. Trent hoped that the computer science course would involve some programming.

Trent felt that the adjustment to college was not dramatic for him. He felt that his parents had given him enough freedom and responsiblity in high school that he was not "held by these chains of restraint." Trent thought that some students did not know how to handle the freedom of restraints suddenly thrown off when they arrived at college.

Though Trent signed on to the e-mail system once or twice a day, I still received no e-mail from Trent until after three weeks of classes had passed in the Winter term. Because of Trent's work schedule it was harder for me to catch him to visit before class. Confusion as to which recitation Trent was in meant that it took until the fifth week of Winter term for me to establish a plan to talk to Trent each week at his recitation.

During the first week I spoke to Trent at his recitation and also after class one day but we mostly exchanged pleasantries. From comments I received from Eddie, one of the other male student research participants who was no longer a computer science major, I knew that Trent and Eddie had talked about their change of majors and their involvement in the research. Eddie's comments prompted me to clarify with Trent that I still considered his input an important part of the research. I made this clarification with Trent after class on Monday of the second week.

I sent e-mail prompts to Trent occasionally through the second and third weeks but did not receive any responses. I did happen to encounter Trent in the computer science lab on Wednesday of the third week and spoke briefly to him as he was in a hurry. He was stressed. He said the term had been really hectic and he had no free time. Trent gave me the impression that he had kept up with his studies but it took all his effort.

At the end of three weeks Trent finally sent an e-mail update as to how things were going for him. He said he felt good about calculus and it was nice to be "in control" again. Trent said that CS 111 was challenging and interesting. He thought it was strange that CS 101, with much time spent on word processing and such, was a prerequisite for CS 111 where "then they make the assumption that everyone knows how to program in C++." He felt that the fundamentals of programming in C++ were skimmed over quickly in CS 111.

I spoke briefly to Trent a couple of times during the fourth week and continued to send prompts for him to send e-mail comments. He told me as he left the first CS 111 midterm that it had not gone well. I talked to Trent at his fifth week recitation but did not

learn any more about Trent's midterm. It sounded like Trent did not finish his CS 111 assignments much ahead of time and contention for machine time in the lab was a problem at times with 180 students in class and a lab of 35 machines. Trent asked if there were any other options for labs to work on assignments. I explained the problems that limited CS 111 coursework to the computer science lab.

At the sixth week recitation Trent was tired and frustrated that he did not have the assignment finished. Kyra forgot to announce that the deadline on the assignment had been extended one week but Trent had a personal extension of a day because of a problem he had with his diskette. Trent seemed stressed by his problems with the assignment and the poor quality of the recitation presentation. As he left recitation he said, "This is bad."

I talked to Trent after class on Friday of the sixth week. He said he did not understand the complaints of students who thought the programming assignments were difficult. The programs were so short and simple that he wrote them at the computer rather than sketching out the logic ahead of time. He thought sketching out the logic would be a good habit to get into for bigger programs but it was not warranted for the short assignments of CS 111.

In recitation the seventh week Trent said he had worked on assignment six for three days. He had been up late the night before and finally decided that he was not going to finish. He was relieved that the assignment was not due for another week. He said it was a good thing he did not realize that or he would not have started on it yet. He thought if he had a good C++ reference he would have finished the assignment long ago. Trent thought a C++ reference should at least have been an optional text for the course.

When I talked to Trent at his eighth week recitation he said he felt good about how all his classes were going. Calculus was "under control." Trent had gone to the CS 111 midterm study session the night before and felt good about the upcoming midterm. He had not gone to the study session for the first midterm because of a scheduling conflict but he had also not done well on the exam. Trent had a night class which conflicted with the study sessions. He decided for the second midterm, however, that a one credit class could be skipped to help him in a four credit class in his minor. At the study session Rick

had gone over the old exam and discussed some definitions of terms. Trent thought it was very helpful and felt good about how the exam would go the next day.

Trent did not attend the ninth week recitation so I did not get a chance to talk to him until his recitation of the tenth week. Trent said he felt nervous about the grade he would earn in CS 111. He was unable to finish assignment seven and he had just received his second midterm results, 42 out of 75. He figured there was a good possiblity he could get a D in the course and he had never gotten a D in his life. Trent said the CS 111 exam study sessions were good and he knew his weekend would be filled with study time for Monday's CS 111 final. Trent ended up with a C in the computer science course, a B in calculus, and As and Bs in his baccalaureate core courses. Trent said he "had a good time" in calculus. He felt good about how he had done in the course.

When I asked Trent in the final interview to reflect on the past term, he commented on how he felt about the two Cs he had earned in his college career (MA 201 and CS 111).

> The two classes that I consider most reflective of being important in studying computer science would be the math first term, and then CS 111 this term. CS 101 was a joke. I don't think that really measures any skills that a person has and those are the only two classes that I've gotten Cs in since I got into college. So I think that probably says to me that I made the right decision in deciding not to major in computer science but it also says to me, well, I didn't fail and I'm still very interested in, I feel like I can do this and it's just a matter of me working a little harder than the average person to get to where I need to be in order to accomplish getting a minor. So I think the fact that I got As and Bs in every other class, mostly As, Cs in these two classes are reflective of the fact that I've probably made the right decision. I can probably do it OK but there's a lot of people who can do it a lot better than me. So I'll look at what I'm good at and do that.

I asked Trent how he felt about himself as a business major.

> All I can say is I'm excited about it. I feel like I can really, I have an apptitude. I feel like I have a sixth sense almost. Something that people when looking for a career, it's something that you just have to look inside yourself and see. There's things that you can force yourself to do because you think that that's what you should be doing and that's what you should

> be good at. And then there's things that you've known all along that you're probably pretty good at but for one reason or another you've suppressed that. I've always had a feeling that I've been good at business.

I asked Trent to trace back through his experience in CS 111. Trent said that initially he was excited about the class and the chance to get an overview of computer science. He felt the instructor knew what he was doing and presented the material clearly. As the course progressed, however, there were concepts that Trent did not understand. "I wasn't really picking up everything that I should and so I was feeling a little anxious about that when the tests came around. I understood [most of the concepts] he was talking about. It was more just all the details coming together and understanding how they all fit in to make the big picture."

As for the programming content of the class, Trent recognized that "they were trying to show us the logic behind the language." Trent felt, however, that he was left to figure out the programming language pretty much on his own.

> They didn't even bother to give us a book for that, which was probably my biggest complaint about the class. . . . The one thing that I could see that that class could be improved by would be to require a C++ class before 111. Then take the series of 111 and 112 because then you wouldn't have to worry about learning the language, you'd already have that as a tool and you could focus more on the logic that is behind it.

As the interview concluded, I asked Trent if he felt his involvement in the study had any effect on how he approached things. "I've never been one to conform to impress people and I didn't think that would do you any good! So, no, I didn't, most of the time, no offense, I didn't even think about it."

Analysis of Trent's Experience

Trent's reflections on his college experience and his unfailing confidence in his abilities were the determining factors in his experience. Trent was as much an observer of

his own experience as he was a participant in his college experience. Trent knew himself well and was confident that college was not a challenge or obstacle in his life path. Trent knew he needed to complete college and he planned to succeed and make the most of the experience. Trent also confidently expected that his abilities allowed him to do well as he competed in his life's chosen career.

Trent's thoughtful and reflective nature had led him to a good understanding of himself and his abilities. In light of his self-knowledge, Trent had given much thought to his long term vision of his career goals. As college started for Trent, he recognized an interest in business but had chosen a computer science major. Trent's choice of major was based on his success in high school mathematics and a desire to make the most of the skills Trent felt he had in problem solving. Computer science was also Trent's chosen major because he saw it as a field with a future. Computer science looked to be a field that offered many opportunities upon graduation and Trent looked forward to his role as a "major player in the future."

Trent's self-knowledge manifested itself in unfailing confidence for Trent in his academic abilities. Trent enjoyed learning in general and was confident in his mathematics and computer programming abilities. Trent repeatedly reported that he enjoyed courses which challenged him, courses which held his interest, and Trent had a broad range of interests. Trent's confidence could have been a dangerous combination with his somewhat unfocused study skills but Trent knew how to study and did apply himself when it was necessary.

Trent was a capable student who did not want to commit himself to the role of a totally absorbed, hard working student. His results in the Fall term discrete mathematics class were less than what Trent wanted for himself because he was not immediately ready in his first term at college to buckle down and invest the time required to master the MA 201 course content. It was not a surprise to Trent that he needed to spend more time on homework in college than he did in high school. Trent was a thoughtful observer of his college experiences and recognized his problems as they developed. If the effort required to attend to academic difficulties was not too great, Trent put in more study time,

arranged appointments with his math professor, and adjusted his schedule to accomodate study sessions.

Although Trent felt that the social adjustment to college had gone smoothly for him, he recognized that his failure to apply appropriate college study skills led to a grade in MA 201 which disappointed him. Because he had his poor study skills to blame, Trent remained confident in his mathematical abilities at the end of Fall term and was anxious to prove himself in the Winter term calculus course. Trent enjoyed the Winter term calculus course, felt good about how he handled it, and was pleased with the grade of B which he earned in the course.

In contrast to MA 201, Trent found that his study skills were not called to task in CS 101. Trent thought CS 101 was slow and undemanding, a class Trent felt was unnecessary for computer science majors who undoubtably had computing experience. With a few weeks remaining in Fall term (and CS 101 and MA 201), Trent decided to change his major to a business major. Trent had learned more of what he thought a computer science career might be and it was no longer something that attracted him. At the time Trent chose to change his major, Trent's image of a computer science career consisted of programmers in front of a computer for 15 hours a day and highly successful computer scientists who were obsessed with what they did. Trent knew himself well enough to surmise that he did not have the drive necessary to be the major player he wanted to be in computer science.

Following his experience in CS 111, Trent again discussed some of the ideas that had led to his change in major. The pace and demands of CS 111 had reconfirmed his impression that computer scientists were obsessed with what they did. Trent thought about how he would compete in his chosen career field. His experiences in CS 111 and MA 201 indicated to Trent that he would have to work harder than the average person in computer science and there were many people who could do better work than he could.

Trent's move away from computer science was reinforced by his experience in CS 111. Trent was confident in his programming abilities but had difficulty completing assignments. Trent had many valid excuses for his difficulties, no C++ reference, a demanding course pace that treated C++ programming experience as a prerequisite, and

contention for machine time in the computer lab. It was also true, however, that Trent's problems were exacerbated by the fact that Trent did not budget much time to complete assignments and could have spent more time studying the material.

In the end Trent's change of major was a move from a field he thought he should pursue, computer science, to a field that was a personal passion, business. Computer science was a field Trent felt he should pursue in order to utilize his talents for problem solving. Business, on the other hand, had been an interest of Trent's for years. Trent had always had a feeling he would do well in business and his dreams for the future revolved around business endeavors.

Throughout the research Trent consistently made time for conversation with me. While Trent occasionally turned to me for answers to technical or bureaucratic questions, Trent clearly valued his involvement in the research for the opportunities it gave him for conversation with someone who cared personally about him and listened to what he had to say. Although much of Trent's conversation was not directly related to the research, Trent enjoyed each opportunity to talk and be heard.

Devon's Experience

Devon was on campus early for Rush Week, a week to visit university fraternities before making the decision to pledge a particular fraternity. Though Devon was on campus, he forgot to come to the e-mail training session for the student participants in the study. I found Devon at the fraternity where he was staying and arranged for the first interview to be the Sunday before classes started. After the interview I spent some time with Devon and showed him how to use the e-mail system.

To start the interview, I asked Devon to talk about how he got interested in computers.

> I kind of like computers. When I was like in third grade my mom got me a Commodore, you know those 64s, way out of date now. I sort of learned BASIC a little bit, load and all that stuff. I like wrote programs that I'd see at school. There's just like a fascination with computers, wanting to learn

> it, stuff like that. Then in high school I took a computer class and since I already had my Mac I was playing around for about a year before I took that class, I mean, it was just like brush up, more fine tuning on stuff I wasn't sure about.

The high school computer class was an applications course, e.g., word processing and spreadsheets. Devon had programmed handheld calculators but Devon's only computer programming experience was work on his own with programs he copied from the Commodore handbook and such.

I asked Devon what he envisioned himself doing with a computer science major. Devon said he was not sure he was in the right field. Devon's only conversation with someone in computer science was with a programmer at Microsoft. "He started describing his kind of job and I was going, hey, that's what I was looking for." At SOAP Devon had told Rick that he wanted to design programs like Microsoft Works. "That's what I want to do." Rick had assured him that he was enrolled for the right classes.

Devon completed four years of high school mathematics and felt that mathematics was his "strongest field." His highest level high school mathematics course was a statistics and functions course. He asked me if the discrete mathematics course was "like the same thing, right? I'm not worried about anything, you know, because my mind works weird. Like, I don't know, I won't even know how to do some stuff and somehow I'll get it right. Just, it works out that way. I just think about it for awhile and not even knowing how to do calculus, I don't know, I'll get it right every now and then."

Devon had chosen to come to the University because he felt that he fit better on a big campus. "I wanted to go to a big university with a big campus." Devon was personable and talkative. He displayed a great deal of confidence in himself. After the first interview, however, I questioned whether occasionally his words clouded or embellished the truth.

Devon had his own Macintosh computer. He assured me he would buy a modem so he would have easy access to e-mail. Phone lines in the fraternity were a problem, however, and Devon never bought a modem or had e-mail access from his own computer. Devon had to go to a computer lab on campus to send e-mail comments to me.

During the first week, I began to doubt that Devon would get his computer set up for e-mail access. He was to meet me after the first class in CS 101 so I could help him set up his computer for e-mail access. I did not see Devon in class that first day. Wednesday I called Devon and found he had not yet purchased a modem. I told him what kind of weekly journal comments I wanted and told him to write them up by any method and give them to me each Monday. I gave Devon my telephone number so he could call for help to set up his modem.

Monday of the second week Devon brought his written journal comments to me before class started. He asked for my e-mail address and said that the purchase of a modem was on his agenda for the day. A few hours later Devon sent me a test e-mail message from a lab on campus. He did not sign on to his account again until Monday of the fifth week.

Devon's comments on the first week focused entirely on CS 101. He commented that his classes had taught him no new material all week. Devon said he hoped that the coming week they would learn something new and actually get homework. "I understand this is the first week and being anxious to get on with this class doesn't make it easy to go through review." I sent an e-mail reply to Devon's comments that in part reminded him that I wanted to hear about all of life not just CS 101. Devon did not read his e-mail, however, so he did not receive my feedback until a week later when I handed him a printed copy.

By the third week I had observed that Devon had a couple of male friends that he usually sat with in class. One of these friends in particular worked hard at giving the impression that he did not need to be in class. Devon's usual pattern was not to take notes but he usually appeared to listen to the lecture.

When I had not received any further comments from Devon by Monday of the third week, I sent another e-mail note and left a telephone message at his fraternity. Since Devon did not read my e-mail responses I decided to write up my feedback and give it to him the next time I saw him in class or at his recitation. Wednesday in class Devon handed his comments to me and I gave him my feedback to his first comments. Devon's second journal comments still concerned only CS 101. He was glad that at least the

computer was used in class (for lecture presentation) but Devon thought that he might want to be in a "higher CS class." I handed Devon my comments on his second journal entry at the next class meeting.

Devon was not in class Monday of the fourth week but it was a basic spreadsheet demonstration day and the instructor had encouraged those students already familiar with the material to opt out on those days. Wednesday of the fourth week Devon and I again exchanged written notes. Devon had more comments written for me and I had written prompts for him. Devon still thought the pace of CS 101 was slow. He did finally comment on something beyond CS 101 and spoke a bit about the discrete math class. "I'm also taking MA 201 which is a logical language which I am having trouble with. It involves implications where the instructor just makes up his own implications and we're to suppose this situation is true and this [is] all too confusing."

Thursday of the fourth week Devon got confused and showed up an hour early for his recitation. I spoke briefly to him but he went to a back corner in the lab and took a nap on a table. On the fourth Friday Devon showed up 40 minutes late to take the first midterm exam in CS 101. Aaron gave Devon about 15 minutes to take the exam. When I talked to Devon a week later, he said he had finished the exam in about 10 minutes and felt he had done fine.

Monday of the fifth week I spoke to Devon at class and he said he would aim to get his comments in the mail Tuesday because he only had one class that day. Monday afternoon Devon signed on to the e-mail system but did not send me mail. When I talked to him after his Thursday recitation Devon told me he could read his mail but not send mail. Devon and I went back into the lab and I helped Devon figure out his problems with the e-mail system. I learned from helping him that though he had told me he could read his mail, he could not read or send mail. Devon was frustrated because he had forgotten the command to get into the mail system once he was signed on.

Devon's system access on the fifth Monday was a sign that encouraged me to send him notes Monday and Wednesday of the fifth week. I was concerned that I was not getting enough information from Devon but I felt I was doing everything I could with the opportunities that Devon gave me. Devon cut my question off short when after the fifth

Thursday recitation I started to ask if there was a means that would work better than e-mail for our research communications. He made it clear that he really wanted to make the e-mail system work. Devon said he planned to send a note every Tuesday from the lab after his recitation.

During our visit after recitation the fifth week, I asked Devon how midterms had gone. Devon thought he had done fine on the CS 101 midterm but he said the discrete math midterm was really bad. He said he needed a tutor. I suggested the Math Learning Center on campus might be helpful and told him I would send him a list of when the TAs worked there. He seemed to appreciate my help. Devon was not in class on the fifth Friday (and had not been in class Wednesday either). When I handed him a copy of the TA list before class the following Monday, he seemed to have forgotten about it.

Tuesday of the sixth week Devon sent an e-mail journal entry. He was pleased that he had figured out how to use the e-mail system. After having done poorly on his math midterm and his geography class midterm Devon commented that "I don't think I quite understand the college difference except that I am understanding it the hard way." He remained bored with CS 101 but figured it would at least give him one A for the term.

Friday of the sixth week Devon sent another e-mail note. I figured he would not sign on to the system again until next Tuesday so I felt badly that I had not sent a reply to his Tuesday note. He reported a good grade on his CS 101 midterm. He also said that discrete math was going better and he had earned some good grades on recent quizzes.

Devon wrote in an e-mail note Wednesday of the seventh week that he was going to drop the discrete mathematics course. Devon's decision came in the same week but before the second midterm in the math course. Devon said his reason for dropping the course was that he did not think he could bring his grade up to at least a C. Devon's other comments in his note were meant to give the impression that he was really into computers and e-mail. "This e-mail is getting to be too much fun. I have cravings of just sending stuff to whoever. It's almost an addiction and I might have to go to e-mail anonymous." I remained less than convinced, however, since the last time he had signed on to the system was the previous Friday. In my reply to Devon I told him that he could retake the discrete mathematics course Winter term.

I spoke to Devon at his Tuesday recitation of the eighth week. He was not in class Wednesday and Friday. When I spoke to him on Tuesday he was upset about points he had lost on the second CS 101 midterm because he had misinterpreted a question. After the recitation Devon hoped he could find Aaron. Devon was headed to talk to Aaron about the exam question. Friday of the eighth week I sent Devon an e-mail note reminder that I had not received written comments from him in over a week. Tuesday of the ninth week I left a phone message at his fraternity.

Devon attended only three CS 101 class sessions out of the eight class sessions held during the last three weeks of Fall term. Monday of the tenth week Devon caught my eye before class and gestured as if to say, I know, you need to hear from me. I left another message at Devon's fraternity Wednesday of the tenth week. I had last heard from Devon Tuesday of the eighth week. I noted in my journal that I was suspicious that his responsibilities to the research were probably not the only responsibilities he had not met in recent weeks.

I spoke briefly to Devon on his way into the final exam and had a good visit with him after the exam. Devon felt badly about losing touch with me for so long but we arranged to get together and talk Wednesday of finals week.

During our conversation after the final exam, Devon talked about how hard it had been for him to get to class the last three weeks. He had not made it to many sessions of his geography class and only a few more of CS 101. Devon ended up with a B in CS 101, a C- in geography, and a B in each of his other baccalaureate core courses. Devon also explained to me that he had to manufacture most of the story about the computer scientist he had chosen as the subject of his term project for CS 101. He was quite proud of the 80 percent that his tale had earned.

Wednesday of finals week I talked to Devon in my office for about 40 minutes. Devon told me that part of the reason I had not heard from him was that his e-mail system password was not working. I told him what he needed to do to get it reset and he took care of it right after we finished talking. Devon told me that his recent nights had been late nights but he was not forthcoming with much more information. He only said it

would be different when he got back for Winter term. Devon said it was just hard to do what was supposed to be done at the end of the term.

Devon talked some about his difficulties in discrete math. He said it was a rude awakening to college from high school. The class did not just follow the book directly. In order to pull the material together, students must do some thinking. He said he would use the Math Learning Center Winter term and the course would go better. Devon also had discovered (too late in Fall term to help) that one of his fraternity brothers was in the other section of the class and did quite well. Devon thought his fraternity brother was good at explaining things and could help him. Devon commented that he was looking forward to calculus. As he had watched others working on it he thought it looked like fun.

I asked Devon about special abilities that he may or may not have used in his college experience. For Devon the question was hard to answer on the spot. Devon talked about how he was the captain and team leader of his baseball team his junior and senior years in high school. His role as captain had meant that he needed to be responsible and set a good example. Devon felt he had done a good job as a team leader. Devon said he had decided not to play baseball in college because it took time and study time was what ended up getting lost.

As we finished our conversation, Devon asked about the research. He wondered if I could just make up data for the weeks I did not hear from him. When he realized this was my dissertation research he seemed to adopt a new respect and recognized that he was involved in an important endeavor . He said I could follow him for three or four terms. I explained that much similar research had used questionnaires. He said he understood how the approach of this research was better. Often on questionnaires he did not tell the truth in his answers. I used his comment as a springboard to reiterate that I wanted the "straight scoop" from him and did not want his manufactured line.

Devon forgot our appointment for the second interview on the Sunday before Winter term classes started but I called him and arranged another time a few hours later. To start the interview I asked Devon how he felt about the term he had just finished. He said he thought he had done poorly but he said he did better than most people around the

fraternity. Devon said he was glad he had experienced Fall term. He was glad he had joined a fraternity and had 80 "instant friends."

Devon said that Winter term was going to be better than Fall term was for him. He said he knew what to do now. He was going to use the Math Learning Center and he was going to use his roommate. He had changed roommates for Winter term and would be rooming with a sophomore who had a 4.0 grade point average. "Our room's like an office. I can work in an office type atmosphere. I can't work wherever there's like a couch or something. . . . First term I had a couch, TV, Nintendo, computer and computer games."

Devon had purchased a desk calendar and planned to be organized and keep on top of classes Winter term. He knew from high school that if he did the appropriate reading before class it helped him learn the material. "I'm going to look ahead. I'll read the chapter and I'll read ahead so when the teacher says something, maybe if I've read it wrong, she can straighten it out. . . . So then it sticks better."

Devon said he always knew that it was important to do the reading and studying before class but he said he had been too busy having fun Fall term. He thought that Winter term would be better than Fall term for him because he was tired of partying. Devon said he tried to be as social as he could Fall term and he did everything except homework. "I'm definitely partied out from the first term. That's going to be a bonus too. . . . It's out of my system."

In his sixth week comments Devon said he was beginning to understand the difference between high school and college the hard way. When I asked Devon what he had learned, he explained that the biggest lesson was time management. "Time management, definitely, sleeping schedule, most of the time I didn't get enough sleeping done. . . . I wasn't organized was one thing." He hoped to pick up good habits from his new, studious roommate. "My new roommate is going to be awesome. He's real responsible. I almost call him dad."

Devon said that it was tough to have CS 101 be such an easy class. "You don't take it seriously. . . . Like a pain in the side, I was glad to be done with that." The discrete math course, on the other hand, was a tough class to have the first term. "I was

partying. I was [doing] fraternity stuff. There was a lot of stuff that we were doing. . . . I'm glad first term is easy, so to speak, for freshmen."

Devon's other comment on the discrete math course was that the course should be taught in a manner that clearly shows how the material applies to computer science. Devon said he paid more attention and put more effort into learning the material when he knew it related to programming. "If you don't know why until like two terms later you're like, . . . , I wish I'd have studied that! I wish I knew that! If they tell me why, I start thinking of new ways of using it."

I asked Devon how he felt about his choice of a computer science major after one term. "Well after I had to withdraw from that one class [discrete math] I was going, now wait a second. But I really won't know until after this term or halfway through it." We talked awhile longer about his roommate and the help he expected from his roommate and then Devon asked, "What do they do in computer science? I mean, I don't know if I'm like in the right field, like, what do usually computer scientists go on to become?" Devon said he loved problem solving and would like to have a job where he could maybe go into a bank and set a system up for them. Devon enjoyed problem solving when it meant an opportunity to make an evaluation of a situation and weigh the options. "I like solving these simple problems which everybody thinks is just a hard task and they're not. They pay a lot of money for that job."

Following our discussion of a computer science major and possible career paths, Devon said that he wished CS 101 also included some information about what kind of jobs are possible in the computer field. "I mean, you don't know what you're going into unless you want to do what your dad's doing and your dad can tell you what you need to do, you know." Devon felt that his advisor could be another source of career information but he had not learned much from those visits either. "When you go to your advisor, . . . it seems like they're brain dead. You ask them a specific question and they go, oh [questioningly]." Devon recognized that the advisors dealt with many students but his advisor visit was his chance to talk to someone in the field of computer science and he wanted to get some answers to his specific questions about his major.

The first week of Winter term classes passed and I did not receive journal comments from Devon. I considered how I might best prompt him and caught Devon after class Wednesday of the second week. Devon said he was headed over to the computer lab right then to write something. He did send his comments and apologized for being late. Devon said that he thought CS 111 was going to be fun. "I really found that what I am learning is what I always wanted to know and I am sure that we are just touching the tip of the iceberg on computer science." Devon was retaking the first term of the discrete math course and he thought it was going great. "I now know what is happening. . . . I now understand and I see other people in the same spot I was when I went through first term."

I also received comments from Devon Friday of the second week. He said he would try to make Friday his regular time to write his journal. Devon commented that CS 111 was becoming more challenging. He commented that he not only needed to learn the material but also account for the "professor's mistakes." He hoped that when he did the reading he would grasp the material. I concluded from his comment about reading the material that Devon had not followed through on his intentions to do the reading before class.

Friday of the third week of classes Devon again sent some comments via e-mail. He seemed to have established a routine for sending his journal comments. Devon usually came to class with two male friends from his fraternity and in three weeks had only missed one class session. Devon's main comment after three weeks was that "before entering this class [CS 111] the students should have taken C++ programming." Devon said he completed his assignments only because his roommate knew C++. "[My roommate] helps me by teaching me what I need for the program and I apply it in my own way to my assignment. What better way to learn?"

Devon also commented in his third week journal that he had not appreciated the lesson of the impostor description for the third assignment. "I got [mad] because I did it last night. Oh well, these assignments are kind of fun. This is what I want to know and why I chose CS as my major."

Devon missed class Monday of the fourth week and forgot to send his journal comments on the fourth Friday. Devon wrote Tuesday of the fifth week and apologized for his forgetfulness. He said that the Friday midterm in computer science had thrown him off schedule. Devon was happy to report a score of 78 percent on his first midterm in discrete math (as opposed to 17 percent on the first discrete math midterm of Fall term).

Devon next wrote on Wednesday of the sixth week. He had missed class twice out of the four class sessions since he last wrote and he said he had been in a cloud lately. He could not remember if he had written the previous week. Devon was tired of making revisions to the same CS 111 assignment each week. "I think it would be better if we were introduced to a new assignment to cover the new material." Devon missed class again Friday of the sixth week and Wednesday and Friday of the seventh week.

Monday of the eighth week I had not heard from Devon in a week and a half but I happened to meet him on the sidewalk. Devon knew he was behind on journals. I told him I felt badly that I had not seen or heard from him in awhile. When I asked how things were going he looked frustrated and hesitated before saying that he hated CS 111. He quickly added, however, that the discrete math course was going well. He said he was unsure what the problem was with CS 111 but said it might help if he studied and read the chapters. He said he felt like assignment six [using recursion] was impossible for him to do. "Has anybody finished it?" He felt that many students did not know how to program. He also suggested that a reference on C++ would be very helpful.

Devon missed his eighth week recitation and class on Monday and Wednesday of the ninth week. I talked to Devon in class Friday of the ninth week. I had noticed that Devon had tried to send me mail on Thursday but he said it had not worked because he did not have the address right. We did not talk about much else because he was going to resend his mail. He did go immediately over to the lab after class but I never received his ninth week comments.

Recitation the tenth week was a review of an old final exam handed out in class a few days earlier. Devon and his two friends did not have their copies and Shawnti had no extra copies. It was difficult at times to follow the review without a copy of the exam and Devon paid little attention to the review.

Devon and I met for the final interview on the day before Spring term classes began. The last time I had received any real information from Devon was Monday of the eighth week. Three weeks of classes, finals week, and a week of vacation had passed since then and Devon's Winter term grades were: CS 111, F; MA 201, D; a pass, a B, and a C in his baccalaureate core courses.

In the final interview I asked Devon what had happened with his plans for the term to be organized and things to go well. "I guess it worked out inversely. [My roommate was] an organizer and I guess I wasn't. I don't know, I think [one] shouldn't like try and copy another person's thing, just do what feels comfortable."

Devon was not sure what the coming term would bring but he knew it would bring a change in majors. "I'm not lost or anything but I'm going to switch majors! I didn't do too hot on computers [Winter] term. . . . I had a bad term. I had a bad term." Devon thought he would switch to a business major. He had looked through texts and homework of brothers at his fraternity and thought it looked interesting and easy. Devon took two years of accounting in high school and he thought an accounting course would be a good way to raise his grade point average.

It was clear in Devon's mind that in the coming term his choice of major was far less important than resuscitating his grade point average. Devon talked about how he was only going to allow himself to go on the annual fraternity and sorority weekend trip if he felt that he had studied enough and earned the right to go.

> What else do I have to do? I'd better not say because usually I tell a good story and it doesn't happen but if I keep back it usually does. I know what I'm going to do. Going to make sure I get grades and stuff like that. It's going to be pretty severe but oh well. I'll still party on the weekends but only when I've earned it let's just say.

Devon felt that he needed to be in college. He felt that college was his future and he was ready to make some sacrifices to find some success. "It's the price you have to pay. Either you have to mentally work or physically work. That's the two things. . . . I'm starting to realize the severity around it because, I mean, look a year's almost over.

Basically if I don't do any good this term I might as well be a freshman next year. Basically I probably will be academically. . . . I'm willing to give up a lot!"

Though Devon's change of major was clearly dictated by his course results, Devon said he did not even like computers anymore. "Not because of the bad grades but going to the class and because, I mean, I thought you were supposed to be taught what was on the test and not like be abstract and make up stuff." I assumed Devon's comment about "abstract tests" was a reference to the second midterm where most of the questions asked the student to write code to solve a given problem.

Devon was frustrated by the demands for programming in CS 111 and his own lack of experience.

> Programming, that's kind of tough when they just tell you to do an assignment. Like, I've never programmed before in my life. How do you expect me to do this? Then they tell you indirectly, they always go around what they want, what the assignment's about. So how, unless you just by blind luck or just by, sometimes I figured it out, one or two times. My assignment average was about an 80%. That didn't kill me. It was the midterms and final that killed me bad.

One of Devon's two friends in the course had, according to Devon, finished CS 111 with nearly 100 percent of the points. "He didn't even study. He'd just know it. So that helped, especially on assignments. I needed to ask like a dictionary. He'd be a walking dictionary so I'd ask him. . . . I would have probably dropped the class if he wasn't in there. I mean I couldn't do the programming.

Devon felt that there was an assumption in CS 111 that students had programming experience coming into the course. He felt that CS 111 was intended to weed out weaker students and give a chance for "the cream to rise to the top."

I asked Devon if he had other frustrations with CS 111. Devon responded by talking about what he had learned about important study skills and what it takes to be a college student.

> There was a couple days [in recitation] where actually I was paying attention and I picked it up but see my problem is that I leave things at the

> class. Pick it up, learn it, and when I leave the class it's just gone. I don't think about it anymore until like maybe later that night if I study I'll go, oh dang, I don't even remember. . . . That's one thing I'm going to do different [this term], after I get out of class you know [go back and study what was just covered]. My grades were pretty bad. I'm going to tack my grades up on a sheet just to remind me every time. I guess I really didn't study that much either, didn't study at all, really. . . .
>
> If there's somebody who's really struggling, who really wants to know and really wants to go into it then they'll, I guess they'll take the initiative to ask people and to find out how they can work and do things better. But, I mean, I didn't even ask. . . . I didn't give it a chance!

Devon also traced his term history in the discrete math course.

> Math was easier to grasp the second time around. . . . Math was going good. . . . I could understand the teacher. [Devon's teacher first term was not a native English speaker]. That was real important. . . . [The] last two weeks of classes, not counting finals week, I sort of fade toward the middle and then try to catch back up near the end, the last two weeks. I went to all the classes in that term except [two or three].

Devon and I talked more about the term ahead and Devon's goals. I asked Devon what interested him about a business major. Devon did not really know. He thought maybe he could be a business lawyer. "My dad's a lawyer. I like to argue and I like business law, go to law school, who knows." Devon's grandfather had encouraged him to take classes to prepare for law school. Devon said that his family had strongly encouraged him to get his act together for college. "I got reamed after they saw my grades! Let's just put it that way!"

As we concluded, I expressed my appreciation to Devon for his participation in the project. Devon responded that "It was pretty fun doing it actually. I got to learn to do e-mail."

Analysis of Devon's Experience

The clear overriding factor in Devon's first two terms of college was the priority he gave to his social experiences. Devon felt he belonged on a big campus and he focused on making the most of the social opportunities available in the major university setting. Devon's acknowledged attempt to be as social as he possibly could be in his first college term, meant that he did everything except homework. While he quickly realized that his social focus led to academic failure, Devon was unable to change his social patterns of activity. Through the second term as well, clear thoughts and good intentions for attention to academics were quickly forgotten when faced with opportunities for social interaction.

While Devon's social life was in itself enough to preclude academic success, Devon also had no clear goal that motivated his pursuit of a college degree. Devon's choice of a computer science major was based on minimal information and even after two terms as a computer science major Devon had only a sketchy concept of what a career in computer science could be for himself. It was not academic interests, the pursuit of knowledge, nor the joy of learning that kept Devon in school. After two terms of disappointing academic performance, it was the threat of a career of physical labor that told Devon he needed to be in college.

Devon's social interest and academic disinterest combined with his unfailing personal confidence to eliminate any possibility that he would invest much time in his school work. As Devon put it, he "didn't study at all, really." Devon's confident comments in the first interview of this research did not hint that Devon expected to study hard in order to be successful in his college coursework. He expected that, even when he was unfamiliar with the material, somehow he would make sense of it all. The realities of his academic performance reduced Devon's academic confidence to some extent but Devon never lost his confidence. He recognized that he was preoccupied with social interests and, therefore, remained confident that with any academic effort at all on his part, he could do good work in his courses.

Devon's involvement in this research was not a factor of significant influence in his first two terms of college experience. Devon thought it was fun to learn how to use e-mail but his research involvement had little other impact. My contact with Devon was limited by his inconvenient e-mail access (and consequent infrequent e-mail use) and his frequent absences from the computer science courses that I attended. Because my contact with Devon was limited, little opportunity was available for "idle" talk. Conversation tended to revolve around academics and Devon's school experience. Devon communicated little about personal interests other than baseball and parties.

In spite of the fact that it took a month for Devon to learn to use the e-mail system, Devon had streaks of consistent weekly research reports via e-mail and handwritten notes. In the latter part of each term, however, Devon was busy (socially) and little, if anything, was heard from him. When Devon again talked to me after a period of no communication, he never wanted to renege on his commitment to the research. He was always apologetic about losing touch. Devon enjoyed his conversations with me and sincerely wanted to help with the research.

Devon was open, relaxed, and willing to talk whenever there was a chance for conversation. The story line that Devon told was frequently embellished beyond the truth but in and around the apparent untruths in his comments, Devon also managed to get to the truth, the real picture of his situation.

The truth wrapped around all of Devon's experiences was the precedence held by social interests over academic interests. From missed interview appointments to missed classes to Devon's own comments about a lack of routine, social involvements were repeatedly indicated as Devon's first focus within his college experience. Devon recognized that his social involvements had a detrimental effect on his academic results but fraternity activities or an opportunity to play pool or video games were much more interesting to Devon than schoolwork. Even Devon's decision not to play college baseball turned into more social time rather than the intended increased study time. Devon was capable of being a good student. He knew what it took to be academically successful but was unable to set aside his social interests in favor of academic pursuits.

When Devon talked about academics, he also talked about friends and social activities. Faced with difficult coursework, Devon never sought to put in additional study time. He always planned to find academic help from his friends. Devon's plan for improved academic results in his second term of college was to find a roommate whom he could count on for help. Devon felt badly about his first term grades until he compared his grades to the grades of others in his fraternity. Grade report comparisons within his social circle did nothing to motivate Devon academically.

Devon's experience in the discrete mathematics course reflected his general college experience. He approached the course with somewhat ill-supported confidence, thoughts that the course would be similar to his fourth year high school mathematics course, statistics and functions. He had no expectations of a challenging and difficult course. After dropping MA 201 in the first term, Devon described how the course was a major change from high school. The material did not follow directly from the book. The thought required to pull the concepts together was a requirement in direct conflict with Devon's party schedule.

As Devon approached discrete mathematics the second time, he lamented the fact that the instructors rarely indicated how the course material was linked to concepts in computer science. Devon felt he could find motivation to learn the discrete mathematics material if he knew something of how he would later utilize the concepts in his computer science major. Devon did not talk much about MA 201 in his second term. His primary academic concern was CS 111. Early in the second term Devon indicated that he felt good about MA 201 and, at the end of the term, the last comment Devon made about MA 201 was that is was going well. Devon's usual overstatement of fact was indicated by his second term discrete mathematics grade of D.

Devon's prior computing experience (and lack of programming experience) set the stage for his experience in CS 101 and CS 111. From his experience, Devon understood computer science and a computer science major to be the use of computers. Devon's experience prior to college left him confident in his computer science abilities.

Devon encountered CS 101 as the first computer science course in his major. As an applications course, CS 101 did not involve the students in computer science, rather,

the course further confirmed Devon's concept of the field of computer science and his chosen major. Because of his prior experience, the course did not grab Devon's interest or enthusiasm.

Devon entered CS 111 with no prior experience with computer programming but, on the heels of his boredom with CS 101, his initial reaction to CS 111 was that he enjoyed the class. Devon was initially enthused to be learning about the concepts covered in the course. Three weeks into CS 111 Devon described the course as challenging but he still seemed to enjoy the course. Devon did feel, after three weeks, that C++ experience should be a prerequisite for the course. By the eighth week, Devon felt strongly that the course operated under the unwritten assumption that students had prior programming experience and the course was intended to weed out weaker students. If not for his friends also enrolled in the course and the help of his roommate, Devon would have dropped CS 111.

Academic results in the first two terms left Devon no choice but to change his major. Faced with this decision, however, Devon did not know where to turn. As a computer science major, he repeatedly expressed his desire for information about computer science careers. He wanted career information to be a part of CS 101 but it was not. He wanted to come away from his advising sessions with career information but the sessions left him disappointed. At a loss, Devon felt that, "You don't know what you're going into unless you want to do what your dad's doing." So, as his third college term started, Devon considered a change to a business major and perhaps a career as a business lawyer — his dad's career.

Eddie's Experience

Eddie was on campus a week early for Rush Week, time for visits to university fraternities before he made the decision as to which fraternity he would pledge. Eddie attended the e-mail training session for the students involved in the study. Later in the day of the training session, I sat down with Eddie for the first interview.

I asked Eddie to talk about his experience with computers and how he became interested in computer science. He started by saying that he had little experience with computers until the past year, his senior year in high school. When the interview was finished, however, Eddie explained that he grew up with computers and computer applications used around the house. Eddie had not taken any classes on computer applications. His dad had a degree in computer science and always had computers at home. Computers were a common tool used in Eddie's home. Eddie explained that his formal experience with computers and programming occurred during his senior year of high school. When he had chosen classes for his senior year, he had been strongly encouraged by his father to take computer programming. Eddie took two semesters of BASIC programming. "At first it was really easy and then it got more challenging and I found myself really enjoying it. You'd get labs to complete and I'd work [on] them at home and stuff, work on them in my head while I was sitting around. . . . [The second semester course] cut down a lot on numbers just because there were a lot of people in there who had no idea what they were doing."

Eddie's experience also included some programming in Logo and he tutored another student in the first semester BASIC programming course. The tutoring had provided some proof to Eddie that he really understood the material because he was able to teach someone else. Eddie minimized his Logo experience and overall said he felt he had "really limited experience with computers."

Eddie told me about the project he had completed at the end of his senior year. He was proud of what he had been able to do. He enjoyed his programming course and felt that the time always went fast when he was doing that kind of work. "It's really satisfying when [a program] does [work] . . . or when it does stuff that you don't expect it to do; that can be kind of fun to work out. You put a lot of effort into a problem and you can see results."

Eddie explained that his dad had influenced his college choice. Eddie had originally chosen to come to the University because of the engineering program. Eddie had taken four years of high school mathematics but a grade of D- in his second semester of high school calculus had made him reconsider his choice of a possible college

engineering major. Eddie expected the mathematics associated with a computer science major to be less demanding than engineering. "I don't feel that I'm math illiterate or anything but it will be a little bit more my pace." Eddie also commented that the prospect of high paying summer internships was one of the "really attractive" aspects of a computer science major.

I asked Eddie to talk about his perceptions of a career in computer science and how he might be a part of computer science. On the one hand, he explained that he had talked to people in computer science and had been told that "it's a sink or swim kind of thing. You either can do it or you can't." Eddie felt he was one of those persons who could do computer science. On the other hand, Eddie said picturing himself in computer science was "kind of the scary part because I do talk to some people [in computer science] and they use all the jargon and it goes over my head."

Eddie told me after the interview that he was most interested in being involved with the research because he was unsure of his choice of major. He wanted to have someone to talk to when he hit moments of uncertainty and found himself weighing his choices.

Eddie's father was a computer engineer for a major computer company. Eddie said he did not see himself working at a place like Intel or Sequent or IBM. He was interested in working for a smaller company maybe as the resident personal computer expert.

As Eddie looked forward to his Fall term courses, he had heard that CS 101 was a basic introductory course but he still said he was not confident in his abilities to do the work of a computer science major. "I'm kind of worried that it will be really easy off, and I'll go 'Yeah, alright!' but then it will kinda get a whole lot harder in a hurry and that's when we'll really find out if this is for me or not."

Eddie said Rush Week had been quite stressful for him. The stresses included life in a new place, visits to different fraternities in an attempt to find where to live, and uncertainty about his major. Eddie said the other field that interested him was architecture but there was no architecture program at the University. His stressful week had caused him to think that maybe he should go to another school and study architecture. "Right

now I'm thinking that if this doesn't work out that's what I'd like to get into." Eddie planned to talk to some people and leave his architecture-related options open.

Monday evening of the first week I received a note from Eddie that said he had amazed himself but he had his computer set up with access to the e-mail system from his room. Eddie faithfully signed on to the system at least once a day for the first seven weeks and then signed on a couple of times a day throughout the remainder of Fall term. When I spoke briefly to Eddie after class the first Friday, Eddie did not want to take time to talk but said he would send me a note and let me know how things were going. Eddie indicated that his dad sent him e-mail each day. I later learned that Eddie also used e-mail to write to his high school girlfriend and a male high school friend, each at other universities.

I received Eddie's first journal comments late Sunday night as the second week of classes was about to begin. Eddie apologized that his comments were late even though his comments arrived by the arbitrary Monday deadline I had suggested to the student participants. Eddie's comments focused entirely on CS 101, a course he described as "interesting, disappointing, and frightening."

In the first week Eddie was fascinated to learn in CS 101 how far computers had come in his lifetime. He felt the CS 101 lab was disappointingly simple. "I'm going to have to be careful not to shrug it off and miss easy lab points." The frightening part of the week for Eddie had been learning about super hackers like Bill Gates and the founders of Apple computers. "I don't see myself as that type of person, or a 'hack' if you will, and even though I enjoy working with computers, I don't know if I enjoy it in the way those guys do (or even other CS majors whom I have talked to) to make a career out of it. Learning about Hypercard and Works for a term certainly isn't going to change my mind."

Eddie's next comments arrived on Sunday night at the start of the third week of classes. I was struck by Eddie's honesty, introspective thinking, and thorough coverage of life in his comments to me. Eddie had gone home for the weekend because he was fed up with the "drinking and other debauchery" at his fraternity. "Any time I have a hard time with math or a hard time in the fraternity, I think I should transfer [to another school] and

take architecture and live in a dorm." Clearly Eddie continued to give thought to his choice of major and had some serious doubts about himself in computer science.

> My dad says architects aren't making any money right now. Making money is important to me, but so is enjoying what I do. I guess one reason I'm at college is to find out which one I value more. Ideally, I see myself making a lot of money designing luxury homes, only it's not really a job because I would do it even if I didn't get paid. I know there are a lot of lucrative internships and starting salaries out there for people who have their stuff together with computers, but its (sic) hard for me to see myself right now doing any of that.

The discrete math course also raised questions for Eddie about his major. Eddie found the course to be difficult and the difficulty worried him. "I'll have to be able to think logically if I want to succeed in computer science. I'm willing to work, I just don't know what exactly to do." Eddie had heard about the Math Learning Center on campus and asked me for more information. I talked to some people and suggested he try to talk to a particular TA in the Math Learning Center.

After two weeks Eddie still found the lecture sessions of CS 101 to be "informative and interesting" but the lab sessions were "lame." He hoped the labs would soon get more difficult. "If it was necessary to think in that class, I wouldn't be so edgy about my choice of a major." In class it seemed that Eddie took notes when the material was new to him and otherwise he just listened without taking notes.

As for the rest of his classes, Eddie described them as "uninspiring and impersonal, as I guess most core classes are." Eddie said his mom was concerned with his large impersonal classes. She suggested that Eddie might go to a community college for a couple of years and then return to the university setting more certain of what he wanted to do.

I replied to Eddie's second journal on Sunday but I also sent a note to him on the third Wednesday to see if he had been able to find help for the math course. Eddie replied to my Wednesday note a few hours after I sent it. He said that he had been able to do some work at the Math Learning Center that day. He thought the studious environment helped as much as anything. "My greatest problem with MA 201 is I don't understand

what I'm doing and I don't know what questions to ask so that I can get answers to help me." Eddie hoped a week and half of hard study before the midterm would change his outlook.

Eddie's note on the third Wednesday also described some of his frustrations with the living situation at the fraternity. He felt some of the obligations of the house were a burden and he felt a bit lonely. "The only time I ever meet girls is when they're drunk, which is great for a lot of people I've come to know, but I don't really go for that. That's probably the worst part of this whole situation."

Eddie still questioned his choice of major on the third Wednesday. Eddie wrote, "I have two lingering thoughts in the back of my mind whenever I have a bad day of classes: one, I could be in a major that does not give me this much difficulty in math, and two, I could be in a major where the introductory classes are interesting to me and not a waste of time and money."

The third Thursday Eddie sent me another note. He was happy with the 25 points out of 30 he had received on the discrete math quiz. The next day, however, Eddie reported that, "MA 201 just rocketed past me today. . . . I hope that I can understand the book because it's all that I can do to copy down the notes but I can't understand them later." A few days later Eddie wrote that he was not looking forward to another whole term of discrete math in Winter term. He hoped he could "get something going" before the fourth week Friday midterm. "It will probably be lots of, but not enough, time [spent studying]."

Eddie also wrote on the third Thursday that he thought he would feel better about his major if he could get involved with it somehow. He asked if I was aware of any clubs for computer scientists. On Friday I found out about the next meeting of the student ACM chapter on campus and sent the information to Eddie. I spoke briefly to Eddie at his fourth week recitation (the day after the meeting). Eddie said the meeting had "really reassured" him about his major. He was excited about the club and felt welcomed by the other students there who were all male upperclassmen or graduate students.

The fourth Tuesday Eddie responded to a note I sent that asked him to reflect on how he was using his talents and abilities in college. Eddie felt he was not using his

musical talents or his talents for computer programming. He was disappointed that so far, college, unlike high school, was not presenting him with situations to analyze and evaluate. He said that any talents he had for math were "taxed" and the fraternity offered "opportunities for using organization, athletic, and leadership talents as well as the talent of relating to people and communication."

Eddie and Trent remembered each other from the e-mail session before school started and they occasionally talked to one another. They were in the same CS 101 recitation and had other chances to talk. Eddie and Trent happened to sit by each other the fourth Wednesday in CS 101. Eddie was able to tell Trent that he had experienced the same password difficulties that Trent had experienced with the e-mail system. Eddie encouraged Trent to try again because Eddie's password had worked for him later.

Eddie wrote another journal note Sunday before the fifth week of classes. He quickly reported that the ACM meeting had kept him going with his choice of major. The CS 101 midterm was easy and the discrete math midterm was not as bad as he anticipated, maybe a C. Eddie talked some about considering a minor in music as it was something he enjoyed and something for which he felt he had a talent. Eddie also reflected about his future in computer science.

> I can see myself working with computers in the future more clearly now. I couldn't before, when I was hating my classes and bored with them. I know that these next five years or so will be the time when I learn about myself and who I am and who my friends are, but right now I just want to get a good job and settle down with a wife I can love and trust and talk to, in my own clean, quiet house with a dog and a rabbit and a garage to keep the cars in. I think the social pressure has a lot to do with this dream. I see myself working with computers because it's a job that requires thinking and could and would be different every day or couple of days, and it's honest. Not like selling used cars is dishonest, more like I go to work and put in an honest day, and am able to go home to a good home.

In his note Sunday before the fifth week, Eddie talked again about his living situation at the fraternity. For the first time, he had stayed over the weekend. The noise and party clean up "demonstrated a lot of good reasons for living out." Eddie characterized himself as an introverted person and said he joined the fraternity so he could

learn to relate better with people. Eddie, however, still sounded a bit lonely. Eddie talked about the importance of my electronic listening ear. "It's just nice to get stuff off of my mind like this, to have someone to talk to. I saw a psychologist in high school just to talk about stuff that's on my mind. That seems to be the role that you've taken on. I don't know of anyone at [the fraternity] I could talk to like this and know that it would stay confidential. If I did, I could imagine I'd have a really close friend by now."

Monday of the fifth week I received a list of hours when TAs who could help with the discrete math course were available in the Math Learning Center. Eddie had asked for this information after two weeks of classes so I sent him a copy of the list.

Thursday of the fifth week Eddie wrote to say that to that point in time he had not enjoyed his time at the University. The fifth Wednesday, however, had been a good day and he wanted to write about it. The day was good because he skipped CS 101, found out he got a B on his discrete math midterm, arranged a study session with a "girl" in his geography class, and made a good showing in an oral test of fraternity history. A friend was to arrange a date for Eddie for an upcoming dance and his "ex- but not really ex-girlfriend, [Chandra]," who attended another university, was delighted with the flowers Eddie had sent for no reason. Eddie counted the days until he would see Chandra. "Right now, [the fraternity] is good, school is good, and girls, here and [at Chandra's school], are OK as well. Those are the three things that matter to me. I figure the future will take care of itself if those three things are good."

Late Sunday of the sixth week, Eddie wrote a two page note after a bad weekend and much time in thought. The weekend was bad because of fraternity parties and cleanup. "You might wonder why I'm in a fraternity, if I don't like, no, hate what they are best known for. I wonder myself, a lot." Eddie said he lived in the fraternity for the benefits of lifelong contacts and an appreciation for living someplace other than a fraternity.

During the weekend between the fifth and sixth weeks Eddie had spent much time thinking about his goals for college and his future. "I think my purpose for being in college is now clear: To acquire the background necessary to support comfortably the family which I will one day have. By background, I mean a degree and internships, but

also social skills for business relations, and making certain that the wife I choose will be my wife for life."

Eddie had also thought about his future in computer science. "I don't know a whole lot about computers, but anything I've ever been taught has been really easy for me. . . . I can picture myself learning about computers (one term, but not this one), liking it, and making a challenging and satisfying career out of it, while still having a family to love and develop."

Eddie mused about why dreams of a family seemed to be frequently in his thoughts. "Maybe because it's hard to have a better goal than to have a happy family. . . . Maybe because I had a very happy family life, and didn't realize it until I left it and came here, and now there's no going back."

Eddie summed up his "ramblings" at the start of the sixth week by saying that there was a lot to like about how things were going for him and there was a lot not to like. "The not to like is ahead at this moment, but the image of my future gets me through it."

Eddie's Sunday journal at the start of the seventh week reported that the sixth week had been good to him. Nothing much had changed in his thinking since the previous week. He had been thinking about next term's courses. He had ruled out a minor in music and asked me to tell him something about CS 111. As a requirement in his freshman orientation class, Eddie had attended a career fair during the sixth week. "I learned that I need to keep my eyes and ears open, make a good resume, and get enrolled in [the University's] placement program. It sounds like a career-related summer job is out there. I just need to go out and find it."

When I replied to Eddie's journal at the start of the seventh week, I assumed that Eddie had been to visit his advisor but he had not mentioned it. I asked him to clarify this for me. He replied that his advisor visit was an experience he would "just as soon forget." Eddie had been greeted rather rudely by the person he thought was his advisor. After some time it became clear that Eddie's advisor was in the office next door and Eddie went over his course choices again with that person. Eddie felt that he was laughed at for the confusion in advisors. "Aside from being embarrassing, I got the feeling right away that

neither one of these guys knew about freshman requirements, much less cared about them." Eddie figured if he were at a smaller school such things would not happen.

Eddie also asked me about e-mail security at the start of the seventh week. He thought that he could write a simple BASIC program that would encrypt messages. If his messages to Chandra were encrypted then others in the computer lab would not be able to read her messages. Eddie's father also signed on to Eddie's e-mail account on occasion and he would not be able to read encrpted messages either. I replied and gave Eddie a couple of options that did not require him to write his own encryption program. I also suggested that he could get another e-mail account through the computer science department (and not tell his dad) if he wanted an e-mail account that was "dad secure." On Thursday of the seventh week I met Eddie at my office to show him how to use some of the encryption utilities. I also showed him the UNIX talk utility. Eddie thought using the talk utility with Chandra would eliminate the need for encrypted messages.

When I talked to Eddie on the seventh Thursday he also told me that his discrete math midterm had not gone well. He had earned a 65 percent. He thought he could still easily get a C in the course and maybe a low B.

On Sunday before the eighth week I sent Eddie a copy of an announcement of the upcoming ACM meeting which had appeared in an electronic newsgroup. Eddie sent his journal comments that day and thanked me for the information and all the help I gave him with his questions over the weeks.

Eddie had taken the second CS 101 midterm during the seventh week. He reported that the exam was easy but he had not studied enough. "I probably got a B, which is not good. I should have an A+ in that class, but it's hard to take it seriously."

Eddie's seventh week had been a good week socially for him. He had the opportunity to spend some time playing guitar with some guys in his fraternity. He had a good time with his date for the weekend party and felt like he came away from it with a friend which was his goal. Eddie had also decided that he wanted to get involved in fraternity leadership. He realized his positive approach to fraternity membership was a major turnaround from what he was thinking two weeks earlier (when he had last written about fraternity life). He decided that the way to make a difference was to develop his

leadership skills and use the power of leadership to make the fraternity a good place to live. "I feel that since I'm calm, organized, serious, and not prone to doing totally inane things, that makes me qualified. . . . Having that as a goal has already improved my feelings towards living here, just as deciding that I want my family to be the focus of my life, and having a job with computers will be my means of supporting them made my outlook on college better."

Eddie missed CS 101 class on the eighth Friday and ninth Monday. I also did not receive his journal comments on Sunday following the eighth week and had not received any other mail all week. Missed classes and late journals were all a bit out of character for Eddie. I sent Eddie a note on the ninth Monday afternoon and told him that I assumed life was going well.

Eddie sent his usual page of "weekly ramblings" on Monday afternoon of the ninth week. Eddie confirmed that when he did not write it usually meant that life was going well. Chandra had come to visit Eddie for the weekend and the fraternity had done a weekend service project in the community. All of Eddie's weekend activities had kept him busy.

Eddie reported that during the eighth week he had filled out an evaluation for his discrete math course. Eddie felt that the professor's accent had been a major barrier. "Being able to understand the teacher is fundamental to learning the material."

Eddie's journals usually ran one to two pages long. Eddie's return from Thanksgiving vacation at home meant that the tenth week started with a four page journal entry on Sunday. Nearly one page was devoted to Eddie's description of a fraternity incident that had caused someone to turn in his pledge pin and leave. "I thought about this all weekend, and how rotten people can be, and how much [the fraternity] is like Lord of the Flies sometimes. . . . What disturbs me more is that I question my decision to live with people for the next three years who have this mentality, and whether I want to be a part of this."

Eddie cited a number of small incidents that made him feel like a guest on his Thanksgiving visit home. The incidents bothered Eddie and made him think. "More than ever I feel like I'm on my own."

Two pages of Eddie's post-Thanksgiving journal were devoted to thoughts of his major and messages Eddie heard from his dad and mom. Eddie had worked on his term paper for CS 101 while he was at home. He needed to ask his younger sister and his dad for help with the computer.

> Asking [my dad] for help is bad for a number of reasons. First, he is not very good at explaining, and his patience is even worse. . . . Since I'm sitting at the keyboard and mouse, I get to demonstrate my ineptness. This makes him question my choice of a major. Also, asking my dad for help gives him a chance to read my paper, which read by a computer scientist is probably unimpressive at best, most likely confusing. . . . Since the time I chose computer science as a major, I have been denying that I have very large shoes to fill. I don't know what my dad knows or does with computers, but I do know that he's a lot more intelligent than he lets on, and he isn't exactly modest either. He asks me about stuff that we're doing in [discrete math], and a lot of it I haven't heard of, but if I have he asks me more details, and it becomes clear that I don't understand what I'm doing. Having a father who is proficient in CS makes it difficult sometimes.

Eddie had also received input on his college choices from his mother over Thanksgiving.

> My mom is a different story. She's a kindergarten teacher, so she has been to a lot of workshops dealing with not only racial bias but gender bias. She sees me being pushed to be a scientist/engineer/businessMAN at the big state university, and my sister being pushed to go into some undefined liberal studies at the small private university. This makes her feel guilty, so she keeps saying, "If you change your mind and/or want to go somewhere else, that's OK." I don't know what I like. I do know that right now I feel like I have been in school for too long.

Eddie also had discussions with his parents about the courses he planned to take Winter term.

> Mom says I should be taking things that interest me and will give me a broader background, not because they are easy. My dad says I should take hard classes now, because it's better to take them now than later. . . . At a perfect college, or even a good one, (I bet they exist like this) I could take

> only classes that I wanted to learn about. . . . Also, I would be able to know if CS was for me a little earlier than sophomore or junior year, when it starts getting hard. One thing my dad said that I don't know what to believe is that it's a myth to expect that you can go through college and just expect to come away with something. You can't just take the classes and get a piece of paper and get a job is what he says. . . . My neighbor, who is about 28 told me no matter what, get my degree. . . . He says that a degree will open up a lot of job opportunities, whether or not the degree is actually related. To employers, a degree says I'm hard working, or at least I can finish what I start. . . . I don't know who to believe.

Eddie sent his next journal on the Monday of finals week. He mused some about what grades he would get in his classes. He figured he would get low A or a high B in CS 101 and something between a low C and a low A in the discrete math course. The rest of Eddie's two page journal discussed his evolving relationships with guys in the fraternity and women. Eddie ended his journal by stating, "This has nothing to do with computers, and once again it is a case of writing this makes me feel better."

Eddie sent another page of "women and relationships" thoughts on Wednesday of finals week. Eddie closed his comments by saying, "As usual, I'll let you know how everything goes." I certainly believed that Eddie would tell me how everything went. I felt that Eddie kept me well informed of all he was thinking and doing. My typical reply assured Eddie that I was listening and let him know that I appreciated my mail from him. It was a message that Eddie must have heard because in his finals week note he commented in regard to a developing friendship with a woman, "She trusts me and has me to listen to her and look out for her (sort of like I have you)."

Eddie and I sat down for the second interview on the day before Winter term classes began. The interview proceeded in much the same style as our e-mail communications. With little input or direction from me, Eddie talked about his thoughts during the holiday break and reflected on his first term in college. Eddie started by talking about the transitions he was forced to make as he entered college. He talked about transitions related to his living situation, leaving home, expectations in college courses, and personal relationships.

> Well, it was of course a **huge** adjustment to make, a tremendous transition in my life. I think living in the fraternity helped me a great deal but also there were a lot of extra burdens that I wouldn't have had living other places. I don't think I would have been better off in a dorm. I guess I'm satisfied with that decision."
>
> It's kind of hard, freshman, first term, they don't care about you, the classes are big and easy, not that challenging. A lot of classes that I didn't want to take but I took because I was fulfilling some requirement and I felt I could have been spending my money and time in better ways.
>
> I didn't have a lot of homework. . . . There's less homework than there was in high school so I think that might have got me into some bad habits or perceptions because I know that there can only be more and I've already kind of got a feel of what it's like.
>
> I was on my own but I wasn't just because there's so many people around me that I could ask. I didn't miss home. And I still don't. . . . I just felt more like I was visiting. . . . I think I've handled that transition pretty well.
>
> More of a personal transition, . . . but I don't have a girlfriend really anymore. Because I was with the same girl for so long I didn't really ever develop any skills for meeting people. . . . That's been a hard transition to make. But that is why I joined the fraternity, so I could develop those [skills] because I didn't want to go through life just kind of being with one or two people, like my parents.

Eddie earned an A in CS 101 and he commented briefly on the course. "As far as the computer class, CS 101, a lot of it was really basic review but some of the things I learned about I'd always kind of heard of but never really understood so that was good. But I don't think it's a good policy to have computer science majors take that just because people who are getting into that probably know everything that's covered in it already or if they don't they'll pick it up easily enough."

I asked Eddie how he felt about the grades he earned first term (CS 101: A, MA 201: C, and As and Bs in his baccalaureate core courses).

> I got a 3.12 which was, actually, exactly what I expected. I got a C in math and that cost me. . . . My parents and I have this agreement that they'd pay for all the A's and B's and I'd pay for everything else.
>
> If you get above a three-point you're on the honor roll in our house [fraternity]. So everyone's been telling me, good job, good job but I know with the difficulty of classes I took that I shouldn't have got below really a 3.8 and I got blasted for that over break by my dad. . . . He has in the past been the kind of person who hires people and interviews people. Like 3.5

> and above is kind of the cutoff, it's what makes you stand out and then everything below that he said you fall into the pool. . . . They can say that all they want but even a 3 point isn't really that good and I agree with him. I felt kind of bad about that now. So I think this Winter term, everyone says, "Yeah, I'm gonna hunker down and study," but that's, just financially and looking towards a career, I mean, that's two big incentives for me.

Eddie said he had thought quite a bit over the break about his dreams for the future. He had also discussed his dreams in conversations with his father.

> My parents and I were talking about what we'd do if we won [the lottery] and I said I'd stay in school just to develop the social skills. . . . I'd learn about real estate . . . and learn more about guitar and cooking. My dad goes, "I didn't hear computer science anywhere in those." He had a point because I was thinking on impulse there and it was apparent that that wasn't one of my top priorities. So that was after I already got blasted for getting bad grades and then there was that.

The realization that computer science was not in his dreams had sent Eddie to the newspaper want-ads to see what kind of work he might like to do. He had ruled out architecture as an option but he had considered careers in music, land development, real estate, and even cooking.

> But the more I thought about it, I thought, "I have the opportunity to go to college [and there are] not a lot of people who do." There are people who do but [it] seems like it would be a real waste if I didn't. I can't think of why but I think in the long run I wouldn't want to look back and go, "Yeah if I'd only gone to college."
>
> So I decided that and then I had another talk with my dad about, what sticks in my mind is he said he worked this summer with high school kids who knew more about computers than I would in four years. I'm sure he was right because during rush week there was that one guy who was a computer science major and it was obvious he knew what he was doing. . . . I don't see myself as that. I don't see how I could make myself competitive because there are people who've been doing that all their life. So he [dad] was thinking, he suggested maybe more of, called it information processing. . . . So he [my dad] suggested looking more towards a business type of career using computers in a computer type of career that happened to be in a business. All the evidence and all my

> experiences seem like that would be a better choice. So I don't know what kind of classes I could take that would lead towards that.

I told Eddie that the business department on campus offered a management information systems degree. Eddie responded that, "I just want to make the switch before it gets too late, before I have to pay for more classes."

Eddie confirmed that most of his picture of the paths open with a computer science major came from his father. "It's hard because it seems more and more like I made a mistake picking a major that not only does he [my dad] know about but that he was in because he can tell if I'm slacking or if I have a clue or not because he'll ask me about stuff that I probably should know that I don't and it becomes more apparent too."

As Eddie looked ahead to the next term he was at a loss to know how the second term of the discrete math course could go any better than the first term had gone. Another guy in the fraternity had tried to help Eddie and that had not worked. "I went to all the classes. I attended every single one of the classes but when it comes to getting help I can't get help if I don't know what to ask. So I think I didn't know what I was supposed to know or I didn't understand what I was supposed to be learning. Maybe part of that is just [the professor's] pace or the accent or what. . . . I don't know what I'm going to do."

Eddie's expectations for the coming term included initiation into the fraternity and improvement in his grade point average. Eddie also hoped he would "get the path I want to take sorted out. Maybe not clear but at least have a better idea if this [computer science] is wrong for me and look to something else." As soon as the interview was finished, Eddie was going to go look at the college catalog and read about a management information systems major. He thought that a management information systems major was what his dad had in mind.

Eddie was in class for CS 111 on the first Monday of Winter term. On the first Wednesday, Eddie was absent from CS 111. I noted Eddie's absence as unusual for him but I also knew his nineteenth birthday was that day. When Eddie also missed class on the first Friday I sent him an e-mail note inquiring as to his well-being. By Sunday night I was somewhat concerned that I had not heard from Eddie. Late Sunday night Eddie sent a note of explaination that his birthday present to himself had been to change his major to

business with an MIS (Management Information Systems) option and a music minor. "I felt bad, because I didn't know how this would affect your research. I feel bad for not writing right away. I don't usually cower like that. Then I ran into [Trent], and he said he changed his major also, and that the survey was over. Is it? . . . When you reply, let me know how I can be of any assistance in the future. I appreciate all that you have done for me. You did help get me through the term, which is primarily why I did your survey."

I replied to Eddie that I was still most interested in how his next term of college went. I wanted him to keep me posted on how his thinking developed as he considered possible career paths and future goals. Eddie assured me that his "ramblings would continue."

In his note telling me of his change of major, Eddie explained what factors had influenced him the most to make that decision.

> First of all, when my dad said there were high school kids who knew more now than I would in four years, it really cut me. I actually always knew that. I guess it was really 12 or so weeks of denial. Meeting the CS major during rush week, and talking with a guy in my house who won some national computing award in high school were always in the back of my mind. I couldn't be able to compete with those guys once I was out of college, was my primary reason for changing.
>
> My other reason was the math class. I really, REALLY didn't enjoy 201, and sitting in 202 the first day, I couldn't pay attention, knowing I had another term of that, with three terms of calculus with physics ahead, and likely I would be struggling and/or paying for those classes I hated until I ran out of money and had to change my major, and would be a few terms behind.

Two positive conversations since his change of major had reassured Eddie that his decision was a good one.

> My first experience with the business department was [Mary], the fairy-godmother advisor. The first thing she did was look me in the eye, and ask "How may I help you today?" compared with [my CS advisor's], "Yeah, what do you want?" When I told her, she pulled down a plan of action, and asked me what classes I had taken. . . . Not only was I not behind, but I was actually a little ahead.

> Then I talked to [Geoff], our house president. He has an MIS option as well. Of course, his word isn't the gospel, but he said it was funny to him that most CS majors end up in MIS positions anyway. [Geoff] took it as something to fall back on. He has a promising future working for his brother, something with mountain bikes. [Geoff's] words dissolved any regrets I ever might have had of changing, excepting how this affects your work, but I know you understand.

Eddie signed on to the e-mail system about once a day during Winter term. I had exchanged a few messages with Eddie at the start of the second week but did not hear from him again until the third Friday. He wrote with a question about the e-mail system and briefly reported on life with him. "My classes are OK [an economics course for an MIS major and three courses in the baccalaureate core], but I have trouble paying attention in them, and fall asleep too often. . . . My living situation isn't very conducive to studying, either. . . . That environmental stress is starting to get to me." Eddie also reported that his fraternity initiation week was to be the coming week and he was not allowed to communicate "with the outside world."

I heard from Eddie again on Sunday night at the start of the fifth week. He was now a brother in his fraternity. He also reported that he needed to get caught up on school work because now he was a week behind.

As the sixth week began I received a two page Sunday night note from Eddie. The note was reminiscent of Eddie's "ramblings" from Fall term but it was the first such note I had received Winter term. He wrote in some detail about his weekend, life in the fraternity, and his feelings of missing Chandra. Eddie mentioned nothing about school and commented that he hoped I found some merit in his ramblings. "This is what I am able to remember to type of my mind. Looking back, it really doesn't say much, but it's what [I'm thinking]."

When Eddie wrote on the seventh Tuesday he reported that there were 31 more days left in the term and he had been counting since there were 58. He reported continuing stresses because of his living situation but hoped that a better room would help next term. Eddie had been elected scholarship chairman of his fraternity. "For the next three terms I am responsible for promoting learning in the house. I think it's a good job

for me. It will make me study more. If I do well, it will show, and if I don't nobody will notice since we're pretty bad in grades right now."

In his note on the seventh Tuesday, Eddie said he had more to write and he wrote it on the seventh Wednesday. Eddie wrote a rambling one page note but the basic message was, "Right now I have no clue at what I want to do. No idea whatsoever. . . . Forests have an increasing appeal to me. I'm going to try and take some kind of forestry class Spring [term]. . . . Maybe I can become a hemp farmer. The problem is that it's still illegal. . . . I guess all I can do is keep thinking and someday I will fill my niche."

After not hearing from Eddie for two and a half weeks, I sent him a note on the ninth Friday telling him I missed hearing from him. Eddie wrote on the tenth Monday. He had a UNIX question and was looking forward to Spring break. He also recognized that he had not been writing as much. "It has been a while. Maybe it's because I have less time, or more people to share my problems with, now that I am no longer a pledge. I by no means have less problems. Probably more. But to write them would take longer than I have write (sic) now. Maybe later." Two weeks later I sat down for the final interview with Eddie.

Eddie told me after the final interview that he truly looked forward to the interviews. I commented that I probably should have picked up on that sooner and made the interviews happen more often. Much as the second interview with Eddie, I gave Eddie a few prompts or questions but mostly he simply talked about what he was thinking. Eddie started by reflecting on the past (Winter) term.

> Last term I got a 2.92 [grade point average, a C in economics, an S, and As and Bs in his baccalaureate core courses] which is not what I had hoped I'd get. I mean it's not like I was partying or goofing around or anything. I don't remember, I don't remember screwing around a whole lot at all when I could have been studying. But then I don't remember studying a whole lot either. I don't remember what I did. Maybe think about cars too much. . . . I just don't think I put in enough effort or took my classes seriously enough and that's why I got a two nine two.
>
> The room I was in I wasn't too happy with. It seemed like a good idea at the start of the term when we picked rooms but one of the guys I was with, all he ever did was watch TV and the other guy had all his friends always come looking for him and that bothered me.

> I learned a lot. The thing I learned most last term was how to study, like how to change my study habits. . . . I've learned during Finals week that it would have been a lot better if I'd read the material before and taken notes. I think that's something you have to do in college that you don't do in high school unless the teacher tells you to. So I'm going to do that this term. I have classes where I need to do that.

I asked Eddie if he felt better about what he got out of his classes during Winter term.

> What bothered me the most was these large classes that I kept falling sleep in. I felt like I learned more in high school when I didn't have to pay for it than I was learning here in . . . basically all my classes. . . . So I was desperately looking, I would have transferred elsewhere if, where it's smaller classes and better quality education, but I needed to know what I wanted to do somewhere else before I paid more money to just kind of float through classes aimlessly trying to figure out what I wanted to do. So that's why I'm still here. Maybe I'll like [pause], depending on how this term goes [pause], it's a combination of getting better grades this term and trying to see if there's something I want to do. . . . It's really all kind of complex.

Eddie was still as uncertain as ever about what he should be doing and where he should be doing it. He had learned from his responsibilities in the fraternity that "no matter what happens I want to be in a position with responsibility where I have direct influence on what happens with my actions." Over break he had considered transferring schools. "I was thinking over the break, thinking a lot, and I knew I wasn't going to get very good grades, conversation was going to come up with my parents, dreams of architecture and designing stuff came up again, which of course isn't offered here. . . . I don't know why architecture keeps coming back." Eddie planned to talk to some architects over the next couple months. He wanted to ask them "how they got into it, if they enjoyed it, what was hard about it, those things."

Eddie had received two Cs in his college career, discrete mathematics Fall term and economics Winter term. "My dad had a point, he goes, you know you've had two classes that maybe remotely relate to what you're going to do and you haven't done that

well in them, that needs to change." Architecture was still Eddie's dream. A business major was only a convenient label, not something to which Eddie was attached. Eddie worried that if he stayed at a school that did not offer an architecture program, he might miss the chance of finding out if architecture really was what he wanted. "I could see myself kind of staying in business. Taking classes for it. Maybe getting into it a little bit, maybe not. . . . Maybe put some amount of effort into it but not really, but just kind of like, it's where I ended up and it's something I was capable of doing so I did it but I could have done something that I really loved but didn't know I loved because I didn't have the opportunity to find out."

As we concluded, I asked Eddie to talk about how he felt his involvement in this research had affected his college experience.

> Well, I got the letter from you last summer saying would I like to be a part of this program and, I mean, I was, "Yeah, sounds like a great deal to me." Because I didn't know much about what I was getting into. I figured that you would be a good place to turn to. And plus I just remembered, in ninth grade my Spanish class, I had to be secretary for the term which meant I had to really pay attention, take notes on everything we did and learned so people who were late or people who were absent could look at those, see what we did. So because I had to pay attention and really know what my experiences were that I got like a 99 percent in that class and learned a lot. . . . So I figured this would be the case if I had to pay attention in the computer [class] and kind of give you an update of it that would really help me a lot. And I didn't really do so much of that, . . . but I think it helped me because it made me think about what I was learning. . . . This program definitely helped that because I had to reflect about things. And when you get to thinking that leads to other things, it just kind of webs out. I'm glad it made me do that. I probably, you know maybe that's what I spend a lot of my time doing, is just kind of thinking about where I was and what I'd rather be doing. And the fact I didn't know probably accounts for why I don't remember a whole lot. I know there's people who just kind of live for the moment and don't really think about anything. That'd be interesting to see how that is. I can't do that. Because you know I always analyze stuff.

Eddie talked some about how I had served him in somewhat of a "psychologist's role" during Fall term but he had found other outlets in friends at the fraternity as time had

gone on. Eddie also appreciated having someone he could turn to with his technical computer questions.

Analysis of Eddie's Experience

The story of Eddie's experience in his first two college terms was clearly marked by three major factors: uncertainty about his broad life goals and, more specifically, his college major, the importance of college social adjustments, and the significant impact of Eddie's father's strong opinions and hard questions. As Eddie struggled with each of these issues, he told his story with great openness.

Eddie was conscientious about his research involvement. He made journal entries faithfully and was apologetic about his decision to change his major. (Eddie was afraid that his change of major might present a problem within the study.) Eddie was thoughtful and reflective in his approach to life and carried this approach through to his research involvement. From the first interview, Eddie was always open and willing to share his reflections on any topic. He knew himself well and had the confidence to follow through on his own ideas. In spite of his confidence, however, as Eddie reflected on his experiences, he often felt that he had not lived up to his capabilities or been true to his dreams.

Eddie looked on his time in college as the time to sort out and establish the goals that reflected his most important values. Thoughts of career and home and family were often intertwined for Eddie. He understood the social pressures that pushed him to concern for earning a substantial income and supporting a family over pursuit of a career in work he enjoyed. Eddie felt he needed to choose between enjoyable work and high salaried work. He saw his time in college as the time that he used to learn which he valued most, making money or enjoying work.

Architecture was the dream to which Eddie most often returned when he was confused about what was important to him and how best to achieve it. From the first interview through the final interview and all points in between, architecture seemed to Eddie to be work he could love. Eddie had some hesitation, however, as he was not sure

he had the skills to compete in the field of architecture. So, as Eddie began college, he put architecture aside in order to pursue a career that he felt was more financially secure and promised to allow support of his dream of a family. Eddie's choice of computer science as this financially promising career resulted largely from his father's influence.

Eddie's computer scientist father held his opinions firmly and strongly communicated his opinions to Eddie. Eddie respected his father and it was difficult for Eddie to counteract his father's strong influence. It was his father who pushed Eddie to attend the University. It was also his father who provided information and firm direction for Eddie's choice of majors. From engineering, before enrolling in college, to computer science, to management information systems, Eddie followed the path of majors his father directed, a path through majors his father respected and with which his father was familiar. On the other hand, Eddie's father discounted a career in architecture saying there was no money in it.

Not surprisingly then it follows that Eddie approached the start of his college career with uncertainty about computer science as his choice of academic major. Eddie's uncertainty about his major was clear enough to him that Eddie chose to participate in this research because he wanted someone to talk with as he worked through his decision regarding his major. E-mail provided an ever-available point of contact with me and it was an outlet of great importance to Eddie in his first college term.

Eddie used e-mail to me as a forum for processing his thoughts about his major but also wrote about everything else that occupied his thinking, from social concerns to life goals to academic pursuits. Eddie recognized that through the process of writing, he found more clarity in his own thinking and he felt better about issues that bothered him. By the second term, Eddie had developed some trusted friendships, thereby, e-mail to me became less important as an outlet for processing his thinking. The value I served as a person Eddie trusted, someone he knew would listen to him and care about his life, however, remained significant to Eddie throughout the length of the study. Eddie made a point to mention in the final interview that he enjoyed and looked forward to the interviews. Rather than any information, technical or academic support, it was the caring

support and my listening ear that Eddie took away as the most important aspect of his involvement in the research.

Eddie's e-mail to me dealt largely with the social aspects of his transition to college. Social challenges drew much more of Eddie's thought and energy than his academic challenges. Eddie found it difficult to meet people, particularly females, and had a terrible time dealing with life in his fraternity. Eddie struggled to find people with whom he could relate and talk. Fraternity membership was something that Eddie chose as a way to learn social and leadership skills. Eddie also wanted the benefits of lifelong, career contacts that fraternity membership promised. He found, however, that he hated the activities for which fraternities were best known and he was uncomfortable meeting people in fraternity social settings. The fraternity living situation in general was a great source of stress for Eddie. Fraternity life frequently turned Eddie's thoughts to transferring to a college with an architecture program and living in a dormitory.

Fraternity life also did nothing to encourage Eddie's pursuit of academic excellence. Eddie's own academic standards, and the standards of his parents, found little honor in the fraternity honor roll mark of a 3.0 grade point average. The fraternity standard for academic excellence was complimented by an environment that did nothing to support one's studies. Between the traffic of people in and out of his room and the ubiquitous television presence, Eddie found it difficult to study in his fraternity. He blamed the fraternity living situation, in part, for the bad study habits Eddie saw himself develop in his first term of college.

Eddie also saw his bad study habits as a reaction to the academic demands of his first college term. Eddie felt that his first term was less academically demanding than high school, consequently, Eddie fell into a pattern of minimal study for his courses. Discrete mathematics, MA 201, was Eddie's only challenging course and he was so confused that he did not know what or how to study for the course. As a freshman enrolled in required courses, rather than courses of interest, Eddie labeled his coursework as uninspiring and impersonal, nothing to motivate dedication to study.

It was a big disappointment to Eddie that he found his academic experience uninspiring and impersonal. Eddie's thoughts of the future were frustrated by his failure to

find meaning and purpose in his present situation. When Eddie was at his lowest, he felt he learned little in his courses and school was generally a waste, other than the contacts he formed through the fraternity. Eddie, and his mother, did not like his large, impersonal classes. Eddie even found his personal session with his computer science advisor to be impersonal, demeaning, and unhelpful. He left his advising session thinking his advisor was ill-informed. Eddie, and his mother, thought frequently about what his academic experience would be like at another school, a smaller school where individual students were valued. When Eddie moved his major to the business department and his new advisor looked him in the eye and asked how she could help, the personal interest was a large measure of assurance to Eddie that his change of major was good.

As Eddie made changes and considered his future, his parents always had support and advice for him. Eddie maintained an ongoing, open dialogue with his parents, a dialogue where Eddie reflected on what his parents had to say. From his mom's concern that Eddie was being pushed, in a stereotypical male style, into science and engineering at a large, competitive university to his dad's repeated indications that Eddie could not compete in computer science, Eddie received a range of input and he gave consideration to it all.

Input from his father was Eddie's primary source of information on the field of computer science and computer science career options. Based on his father's information, Eddie approached his freshman year as a computer science major with a sense of reality. Eddie knew that the math requirements of a computer science major would be demanding. He knew that there was more to computer science than computer programming and, therefore, while he enjoyed programming, Eddie approached computer science unsure that computer science as a major was the right choice for him.

Eddie's math background was adequate but he had not been successful in all his high school math courses. Based on his high school experience, Eddie was not overly confident as he faced the mathematics requirements of a computer science major. After only two weeks in MA 201, Eddie was painfully aware of the difficulties held for him by the discrete math course. The fast pace of the course and the professor's strong accent exacerbated the problems Eddie found in his attempts to understand the course content.

Quickly Eddie was too lost to ask questions or benefit from class lectures. Throughout the term, Eddie struggled, tried tutors, and studied intensely but confusion, frustration, and discouragement were the only results.

The serious difficulty that Eddie confronted in MA 201 was major evidence to him about what he saw as his potential for success in computer science. Eddie's father only added to Eddie's perceptions of inability when Eddie was at a loss to answer his father's questions about discrete math. To Eddie his experience with discrete mathematics was a reflection of what his experience would be in computer science.

Eddie saw computer science as a field wherein some people did and some people did not have the skills to succeed. A positive experience in his high school computer programming class gave Eddie confidence in his programming abilities. Comments and hard challenges from his computer scientist father, however, left Eddie easily intimidated by the knowledge of persons already at work in computer science.

Although Eddie had grown up with computers and computer applications used in his home, Eddie felt he had little experience with computers. Eddie was anxious as he began his first term of college, because he knew he needed more than programming skills to succeed in computer science. His first term coursework, however, did nothing to relieve his apprehension. Eddie found himself enrolled in CS 101, a course in computer applications. Eddie was upset that he learned so little in the course. He wanted to do some programming. Eddie longed to be involved in his major and learn more about it.

Disappointed that the content of CS 101 held no challenge nor computer science insights, Eddie became more nervous about his ability to meet the real demands sure to face him in future coursework. In his struggle for assurance that he had chosen the correct major, Eddie wanted to be in a course that would tell him something about his computer science skills not waste his time with computer applications. Eddie could make good use of computer applications but did not do so confidently. The ins and outs of computer use held no fascination for Eddie. Eddie's lack of fascination with computers was yet another sign to him that computer science should not be the field of his life's career.

Eddie's apprehension and questions were magnified by his father's comments about Eddie's substandard computer science skills and his assured inability to compete in the field. Eddie's father used his computer science knowledge to put Eddie in a position where Eddie felt inadequate in his abilities. Between his father's comments, and brief conversations with a few people in computer science, Eddie was convinced that he could never compete in computer science. Difficulties with discrete math, an inability to compete in computer science, and the impossible challenge of living up to his father's standard, made it clear to Eddie that computer science should not be his college major.

Analysis of the Experience for All Student Participants

Significant factors were common to the experience of all student research participants. Clearly all the student participants had little informational basis for their choice of a computer science major. The students based their concept of the field of computer science on their experience. Their experience was, for Samantha and Devon, the use of computer applications and for Heather, Trent, and Eddie, some computer programming. Because their choice of a computer science major was based on minimal information, the students had a keen interest in information about a computer science major and computer science careers. The students were disappointed that, in their first two terms, they learned little about what their options might be in the field of computer science. The students were forced to use their coursework experience as their primary indicator for the entire field of computer science.

The students all held expectations that sessions with their advisor were an opportunity to talk to someone who was a source of information about a computer science major and a career in computer science. In their experience, however, students found their advising sessions unhelpful, intimidating, and demeaning, an inconvenient formality for a signature on an enrollment form.

Special WISE events were more comfortable than advising sessions for Heather and Samantha. The WISE events gave students an opportunity to establish a dialogue with some of their professors. Heather and Samantha both appreciated the contacts and

information that resulted from their attendance at WISE events. Contacts with other students living on the WISE dorm wing were also a valued source of support for both Heather and Samantha.

Devon and Eddie were able to connect with other, male, computer science majors in their fraternities. (Trent was not interested in making contact with other students.) For Devon and Eddie, their contacts with other students served as evidence that others knew what they were doing in computer science and Devon and Eddie could not compete.

A common experience for the male student participants was their concern for gauging their ability to compete in the field of their chosen career. For the males, their chosen major needed to be a field where they could find financial success after leaving college. Eddie and Trent were discouraged by their perception that top notch computer scientists were obsessed with their work. The female student participants' overriding concern was that their college major involve them in work that they enjoyed and found of interest.

The transition from high school to college presented academic and social challenges. Moffatt (1989) documented "friendly fun" as a mainstay of college life. Clearly for most college freshmen, social challenges, opportunities, and adjustments likely hold a high priority for a student's time and attention. For Devon and Eddie, living in a fraternity exacerbated the negative influence of social pressures on their academic success. While social pressures challenged all the student research participants, Trent to a lesser degree, all the students appreciated their research involvement as an opportunity for contact with someone who personally cared about them. The students' responses to interviews and informal opportunities to talk to the researcher and the students' use of e-mail conversation with the researcher clearly indicated the importance of their contacts with the researcher. While being challenged academically and socially in a large, impersonal university setting, the students valued someone who knew them, listened to them, and cared about them.

E-mail was particularly important to Heather and Eddie as a point of contact with the researcher. For Heather, e-mail conversation was more comfortable than face-to-face conversation. Heather had much more to say via e-mail than in person. For both Heather

and Eddie, the process of writing e-mail provided an outlet for processing their thoughts, an outlet that was available any time of the day or night.

The academic challenges of college stretched students' study skills and forced them to make difficult choices in time management. In discrete mathematics, students found that their high school mathematics experience was inadequate preparation for the proof intensive nature of the courses. In CS 111, students were challenged by a fast-paced course and a practical, but not formally specified, demand for prior programming experience. The students faced the challenges of CS 111 with the support of a poor text, no programming language reference, and teaching assistants who did not enjoy teaching. Most students' study skills in their first two terms of college were not adequate to meet the challenges offered by the discrete mathematics courses and by the pace of CS 111 with its demands for computer programming.

The students were not the only ones who faced challenges in CS 111. CS 111 was also a demanding course for the instructor and the teaching assistants. Rick expected his lowest teaching evaluations to come from CS 111. This research was not designed to provide Rick with helpful feedback on his teaching but Rick longed for input on improving his teaching in CS 111. As Rick observed, this study clearly indicated the potential benefit, to the instructor and to the students, for a course observer to serve as a liaison of information between the instructor and students in the course.

As the students faced the various challenges of their freshman year in college, family support was an important factor for some students. In particular, those students with fathers in computer related careers, Samantha, Heather, and Eddie, had fathers who took an active interest in the students' academic pursuits. (Trent and Devon made little mention of their families.) For Heather and Samantha, their fathers' interest was expressed in ever available support and encouragement. Eddie's father, in stark contrast to the female students' fathers, was for Eddie a constant source of discouraging reality and an indicator of negativity on Eddie's ability to compete in the field of computer science.

It is important to note that most of the subtle factors operating within the culture of computer science education, for example masculine language or a competitive environment, were not mentioned explicitly by the students. Certainly many potentially

discouraging factors in the culture were observed in this research — classroom questioning interactions that were avoided by women, lecture examples and pronouns that were biased against women, and an air of competition evidenced by difficult courses and "impossible" exams. Students in this research did not complain about computer laboratory settings. They were not inhibited by the physical laboratory setting and appreciated the laboratory environment for the access it gave the students to other people. Although Heather was uncomfortable at the ACM meeting and students found meetings with their advisors intimidating, the myriad of similar factors, that were the subject of much prior research, were not raised by the students in this research.

The depth of student experience data captured in this research, produced clear results. While the students did not mention subtle factors of potential gender discrimination, the students were open and honest in their discussion of more obvious factors in their experience. All of the students knew little about careers in computer science and the students were anxious to learn more about career possibilities. The female students were concerned that their career involve them in work they enjoyed. The male students needed assurances that they could compete and find financial security in their career. As the students made the transition to college, they were faced with significant social and academic challenges. In the face of challenges, the students valued support they found in a variety of forms — WISE events, family, researcher contacts, and other students. On the other hand, the students were disappointed in the lack of support found in time spent with their advisors. Within the prescribed computer science curriculum, students struggled, with inadequate study skills, to meet demanding course expectations and were particularly challenged by mathematical proof and computer programming concepts. Students not experienced with mathematical proof or computer programming could not keep pace with course demands and failed to develop an understanding of the basic principles in the respective course. Student difficulties were matched by the struggles of teaching faculty as they looked for input to support improvement in their teaching.

Although the reasons were complicated and unique for each student participant, the students' moves away from computer science highlight the need for changes in the

system of computer science education. It is unfair to assume that those students who choose not to be computer scientists cannot be computer scientists. Sadly, however, the student experiences in this research revealed that potentially excellent computer scientists, women and men, are weeded out by the current system.

CHAPTER V
DISCUSSION AND CONCLUSIONS

Introduction

For many freshmen their declared college major is a minimally informed "best guess" of their actual college major upon graduation (Erickson & Strommer, 1991). Based on Office of Technology Assessment data (1988), it is estimated that by the time college majors are completed, 50% of the men and 80% of the women who originally intended science majors complete majors in other fields of study. In contrast, 30% of the students with an original intent to pursue a business major move to other fields. Forty percent of the originally intended education/social sciences majors opt to complete other majors. In the pool of students who opt out of computer science, what Tobias (1990) calls the "second tier," valuable creativity, talent, and perspectives are lost from the further development of the field. The results of this research describe the experience of freshman computer science majors and identify factors of influence in student decisions of persistence within computer science.

Although a concern for gender equity provided the framework for this research, the results of this study highlighted the fact that the question of equity should be broadened to include concern for the tier of talented women *and men* who currently choose not to persist in an undergraduate computer science major. Subtle elements of potential gender discrimination were a part of the rich data collected in this study but the students did not mention such factors. The students identified factors of importance unique to their experience as computer science majors, however, as first year undergraduates, many of the factors identified by the students were found in the general undergraduate experience and the students' transition to college.

Three of the students had fathers whose careers involved work with computing. For these three students, their fathers were significant role models and sources of support in their academic endeavors. In their course work as computer science majors, the students encountered significant difficulties with concepts of mathematical proof and computer programming. Course difficulties were interpreted by students as messages about their ability to succeed within the field. Students not experienced with mathematical proof or computer programming failed to develop an understanding of

the basic principles in the respective course. Student difficulties were matched by the struggles of teaching faculty as they looked for input to support improvement in their teaching.

Many of the factors of importance in the students' experiences were elements in their general undergraduate experience. All of the students knew little about careers in their chosen major and were anxious to learn more. The female students wanted their career to involve work they enjoyed. The male students wanted assurances that they could compete and find financial security in their career. The students valued support they found in a variety of forms and were disappointed in the lack of support found in advising sessions. Students struggled with inadequate study skills to meet demanding course expectations while also giving time and energy to the social demands of their college life.

This chapter discusses the results already presented and provides interpretation of these results in light of the research literature. Limitations of this study are also discussed but, in light of the limitations, important implications of this research are outlined. The research results point to obvious needs for change in computer science education. This chapter also suggests avenues for further research that expand on the firm foundation established in the results of this research.

Interpretation and Discussion of the Results

A research outcome of interest is the fact that none of the students cited subtle factors of potential gender discrimination that have been the point of interest of much research literature. Though observed by the researcher, students did not mention perceiving the following: competitive and individualistic environment, male dominated classroom interactions that demanded assertive involvement, nearly exclusive use of male pronouns and examples in discussions of computing, "questions" by men that were attempts to show how much they knew, demonstrations by men in CS 101 and CS 111 that they did not need to attend class sessions, or a myriad of other factors that typically have been found to operate in subtle rather than explicit fashion. The data of this research concur with McIlwee and Robinson's (1992) finding that, "Many [female engineering students], especially in their college years, were blissfully unaware of the dynamics of tokenism and sexism that swirled around them. Even those who

later would develop a consciousness of these issues were quite naive about them at this stage" (p. 69). Because the research was an attempt to capture what was significant to the participants, the researcher did not dictate topics for the participants' reflections. While the students may have noticed and reacted to certain subtle factors, students chose, in conversation with the researcher, to discuss more explicit factors in their experience.

The factors of importance in the students' decision making with regard to their college major were, with the exception of significant family support, all factors that can be affected within the current system of undergraduate computer science education. While some of these significant factors have been suggested in the research literature, data from the current study illustrate how factors are perceived in the experience of college freshman computer science majors. Student experience must direct changes in the system.

Three of the student participants, Heather, Samantha, and Eddie, had fathers who worked in computer related careers. Father's job type has been indicated as a significant influence on freshman career aspirations (Dunlop & Canale, 1988). In particular, Fitzpatrick and Silverman (1989) and Houser and Garvey (1983) found that the father's influence was particularly important for women in traditionally male-dominated fields. Heather and Samantha both knew that their fathers were always available for positive support of their academic efforts. Their fathers' support was a frequent source of encouragement for Heather and Samantha. For Eddie, on the other hand, his father's support came in the form of assurances that Eddie would not be able to compete in the field of computer science.

All of the male student participants wanted their college major to lead to financially secure employment after college. The female student participants wanted their college major to involve them in work they enjoyed and found interesting. The males wanted to be sure that they could compete successfully in the post-college job market. Computer science was perceived to offer financial promise but only if one was a step ahead of the competition. The career orientations of the male students were traditional for males — focused on fields with status and potential for material gain (Sax, 1992; Strange & Rea, 1983). In this light, clearly Eddie's father's input was bound to carry significant weight in Eddie's decision making. Also in agreement with previous research was Eddie's and Trent's search for a concept of the successful

computer scientist. Eddie and Trent developed concepts that portrayed successful computer scientists as persons obsessed with their work, a characterization that other students have also made and found discouraging (Martin, 1992; Rasmussen & Håpnes, 1991; Turkle, 1984). To both Trent and Eddie, obsession with work was intimidating and they were no longer interested in pursuing the work of a computer scientist.

All of the students chose their computer science major based on a poor concept of the field of computer science. The pattern of minimally informed major selection has been documented in the literature: "Majors are often selected with virtually no knowledge of the field and for the flimsiest of reasons" (Erickson & Strommer, 1991, p. 32). What the current study clarifies, however, is that as students begin their freshman year in college, they are groping for any information that illuminates the correctness of their choice of major. With few known sources of information, students approach their first courses in their major not so much to learn the content but to learn if their major is the right choice for them. The messages Eddie read in his difficulties with discrete mathematics might have been different if he had been concurrently enrolled, and successful, in a "real" computer science course.

Students also looked on their sessions with their advisors as an opportunity to ask questions about their major. Universally, the students in the current study were disappointed in the time with their advisors. Advising has been recognized as a weak link in the undergraduate experience (Erickson & Strommer, 1991). In spite of the recognized problems in the advising process, faculty perform their advising responsibilities with little training. Students quickly come to the conclusion that their peers know more than their advisors about the curriculum (Moffatt, 1989). For the students in the current study, only one session led the students to realize that the advisor's role was to provide a signature on an enrollment form, not to provide information or answers to questions.

Not only did the advising sessions fail to provide information to the students, but the setting for the sessions was intimidating to students. Students had never met their advisor before their first advising meeting and had no contact with their advisors outside the once-per-term sessions. Obtaining a signature on an enrollment form was much easier than establishing conversation with a faculty member students did not know (and who did not know them).

Although the students valued contacts with people who provided information, it was at least as important to students in a large, impersonal university setting to have people who knew them and listened to them. College freshmen are faced with expected and unexpected academic, intellectual, and social challenges that are most pronounced in the first few months of the school year (Feldman & Newcomb, 1994). All of the student research participants appreciated their involvement in the research as an opportunity to be listened to with care and asked to talk — given the opportunity to talk about the important issues in their life rather than talk about topics that someone else had chosen for them. For the student participants in this study, contact with the researcher, in person or via e-mail, was a welcome opportunity to talk about what was important to them rather than a chance to pump the researcher for information. The researcher was viewed as an experienced peer who had previously shared some of the same experiences and, therefore, listened with understanding. Whether the challenges were academic or social, the students valued having someone with whom to share their thoughts.

Research contact with the students via e-mail was a significant aspect of this research. Particularly for Heather and Eddie, e-mail was a comfortable mode of communication. Heather never had much to say in a face-to-face conversation or interview. Additionally, indications were that a conventional journal, written but non-interactive, would not have captured many of the thoughts and feelings expressed in student e-mail communications.

The students viewed academic interests as the focal point of their research involvement but social issues were a large part of their college experience. Social aspects of their lives were not overlooked in the students' reports to the researcher. Forced to leave the comfort and support of family behind, students must develop a new set of relationships and community of support upon entry to college. The students invested at least as much time and energy in their social agenda as they did on their academic commitments. For the males living in fraternities, Devon and Eddie, the living situation was a clear detriment to their academic pursuits. Eddie was frustrated by his suffering academics. Devon reveled in his active social calendar. Undergraduates are typically surprised that they cannot neatly balance academics and college life (Erickson & Strommer, 1991). Heather recognized that she was too frequently distracted from her studies but was powerless to significantly change her

behavior. Samantha recognized her ability to balance her studies and her social life as a major accomplishment.

When students come to college, they expect to study harder in college than they did in high school. In spite of their good intentions, however, they begin college with little idea how to actually begin studying (Erickson & Strommer, 1991; Moffatt, 1989). Devon was never able to give priority to his studies. Even when Heather saw problems in her studying, she was unable to make changes. While Samantha completed her programming assignments in a timely manner and always found a computer available in the laboratory, Trent worked closer to the deadlines and often found it difficult to get computer time in the laboratory. Eddie's boredom with baccalaureate core courses did not motivate him to develop good study habits. Eddie wanted to learn but was uninspired by his first year of courses, a problem noted in the literature. "Impatient to specialize, [freshmen] do not find the liberal arts core or a general education program relevant and view those courses as another irrationally imposed set of requirements" (Erickson & Strommer, 1991, p. 33).

Advising and classes were the students' only contact with the University computer science department. As these freshmen searched for assurances about their major, it did not help to feel out of touch with their major department. Eddie went to an Association for Computing Machinery (ACM) meeting in an attempt to make some connection with his major. Eddie felt welcomed at the meeting and was left feeling some connection to his major. Heather was extremely uncomfortable at the ACM meeting she attended as the only female. As women find their way in the male-dominated field of computer science, university sensitivity to the maleness of the environment can help women feel that they have a place (Caplan, 1993). Heather and Samantha felt much more comfortable in settings that were a part of the WISE (Women in Science and Engineering) program. They valued the contacts made through the WISE program with faculty and other female students. Unfortunately, research has found that a lack of support has existed in departments like computer science. Tobias (1990) found that, "Science concentrators tended to rate their department of concentration as considerably 'less supportive' than other departments" (p. 72-73). In similar fashion, Hearn and Olzak (1981) found that, "Departments providing higher status rewards tended to have less supportive social climates" (p. 200).

In their first term, the students in the current study were faced with a most difficult challenge to their study skills, MA 201, discrete mathematics. With high school preparation that included little, if any, experience constructing mathematical proof, the students found themselves in a course that was proof intensive. Within the University mathematics department it was recognized that juniors and seniors were more successful in the course than freshmen and sophomores. Mathematics majors completed the calculus sequence, which contained virtually no mathematical proof, during their freshman year and completed discrete mathematics following at least one year of university mathematics experience. Some of the graduate students in mathematics, who served as resources in the University Math Learning Center, did not have the mathematical background to assist students with the MA 201 course content. For all of the student participants, their experience in the course was discouraging. Samantha, who enjoyed mathematics and was no doubt mathematically talented, managed to earn a B in the course and knew it was an accomplishment of which to be proud.

The University computer science department considered the content of MA 201 a prerequisite for CS 111. As Devon, who took MA 201 twice, remarked, students count on making connections from their major to their supporting courses. For freshman computer science majors, with little or no concept of the field, supporting course connections must be made explicit by course instructors. Rick, the head undergraduate advisor, recognized, however, that the mathematics department did a poor job of making the links to computer science in MA 201. Rick wanted to make connections to MA 201 in CS 111 but never managed to realize his intentions.

CS 111 was designed as a course to present students with a broad overview of the field of computer science. Homework assignments for the course, however, focused student attention on understanding programming concepts. Unfortunately, in the organization of the course, the instructor's intention was to confine lecture to general topics in computer science. The burden of teaching programming concepts was relegated to recitations as the responsibility of graduate teaching assistants, some of whom did not enjoy teaching nor excel in its practice. While the instructor recognized a need for supplementary instructional time on programming concepts, and devoted additional lecture time as needed, frustrated students were focused on completion of homework assignments rather than interested in programming principles.

The conflict between instructor goals for teaching principles and student focus on assignment completion has long been a problem in computer programming courses (Sproull, Kiesler, & Zubrow, 1987).

As students struggled to complete their programming assignments, they found themselves primarily concerned with issues of syntax. The time required to resolve syntax issues left students with little time to consider questions of program logic. Students somewhat blindly followed closely related program examples and were able to complete assignments with little understanding of the underlying logical concepts. The demands of the programming assignments absorbed virtually all of the students' attentions for the course. The students falsely assumed that if they could complete their programming assignments then they understood the course material.

Rick's surprise and lack of understanding with the poor student performance on the second CS 111 midterm exam, an exam focused entirely on programming principles and programming code, highlights the ease of teaching programming language syntax versus the difficulty of teaching programming logic. The results of the second exam discouraged students but the "difficult exam" scenario occurs frequently in introductory programming courses (Harrington, 1990/1991). As found in Harrington's research, students in the current study were intimidated by the difficult exam and felt badly enough to consider a change in major.

Rick wanted to improve the level of instruction in CS 111 and he clearly expressed a desire for information that would help him address problems within the course. Rick recognized that the researcher was in a position to gather information potentially useful for improving teaching. As the researcher observed the course and talked to students, Rick was disappointed that, because of research constraints, he was not able to share fully in the researcher's understanding of the students' experiences.

Important in the students' experiences in CS 111 was the fact that the pace of instruction and demands of assignments made a clear, yet unofficial, demand for prior programming experience as a prerequisite for success in CS 111. The unwritten expectation of prior programming experience is characteristic of introductory programming courses (Harrington, 1990/1991; Sproull, Zubrow, & Kiesler, 1986). Combined with the reality that females have less experience with computing than males (Clarke & Chambers, 1989; Teague & Clarke, 1991), the demand for programming experience is destined to discriminate against females.

In addition to the CS 111 course difficulties already discussed, students were supported in CS 111 by a poor text and no programming language reference. The instructor and the students all agreed that the text and lack of language reference were problems. Sadly, poor reference materials are not an uncommon problem in computer science courses (Harrington, 1990/1991). Publishers struggle to produce quality materials while keeping pace with a field that changes with incredible speed.

Limitations of the Study

One of the strengths of the current study, the depth of data collected from the participants, necessitated a small sample size. The small sample size precluded broad generalizations from the results but was a manageable size for the researcher to capture a complete picture of the participants' experiences. In consideration of the results, therefore, it must be remembered that the results developed out of the experience of only five students in a single university setting. Some results are unique to the research setting and some results are a product of specific participant characteristics. The goal of this research was to capture an in-depth description of the experience. From the rich description offered by this research, only individual determinations of similarities allowed the results of this research to be generalized to other settings.

Also in the design of a manageable study, the study was limited to the first two terms of the college experience. Experiences within initial courses in a field are significant in student decisions to persist within a major (Beaudin, Horvath, & Wright, 1992; Lipson & Tobias, 1991). Certainly, however, the choice of an undergraduate major is a decision that remains under consideration until a student's graduation. In capturing the first two terms of experience, this study is limited to suggesting changes in the first two terms of undergraduate computer science education. No doubt there is room for improvement in the system throughout the undergraduate program.

As the study evolved, it resulted in descriptions of students who had changed their major or were destined for a change of major based on their expected academic success in future computer science courses. Trent, Eddie, and Devon had all changed their major by the end of the study. Heather's difficulties with the mathematics requirements of a computer science and her inability to generate much academic effort

suggested that she would change her major once she found another field of interest. Samantha's lack of prior programming experience and failure to grasp concepts of programming logic in CS 111 prepared her for failure in future computer programming courses. Although this research failed to provide a description of the experience for successful computer science majors, other research, for example, Harrington (1990/1991) and Turkle (1988), has presented the experience of successful computer science majors while ignoring the experience of the non-persisters.

The design of the research involved the researcher for all of the data collection. Recognizing the potential for researcher biases to distort the data, care was taken to bracket researcher biases. Researcher background and biases were acknowledged before the study began. A researcher journal, a record of researcher reflections on and perceptions of the researcher experience, was kept for the duration of the study. The researcher journal informed data collection and analysis by confining data to the participants' perspective removed from the researcher's prior experience as a female computer science student and instructor.

True to this study's concern for the participants' perspectives, meanings, and interpretations, the study was limited to topics the participants perceived as important in their experience. The researcher did not affect the participants' experience by introducing topics for reflection by the participants. Factors such as possible subtle gender discrimination issues may have been perceived more important by the researcher because of researcher bias. In keeping with Wolcott's (1988) caution, the researcher made every attempt not to serve as an interpreter for the participants. Much other research has focused on subtle, and explicit, gender discrimination. Of importance in this study is the fact that the participants did not mention many of the gender discrimination factors considered by prior research despite the presence of such factors.

The participants in this study, student and instructor, were immediately open and trusting in their conversation with the researcher. Throughout the study, however, there were occasional signs of participant confusion about the researcher role. The student and instructor participants were more familiar with the role of a mentor and, at times, expected the researcher to be more of a source of supportive information. The participants always saw the researcher as a person who listened to them but at times they made attempts to predetermine what topics were of particular interest to the

researcher. While some confusion was present with regard to the researcher role, overwhelmingly the data of this research were characterized by incredible openness and trust.

Implications

This research observed many factors of gender discrimination within the classroom experience in computer science education, however, these factors were not mentioned as significant to the student participants. Subtle factors in the students' experiences were overwhelmed by more obvious factors in their general experience as first year undergraduates. The results of this research compose a clear portrayal of glaring inadequacies in the system of undergraduate education while also having implications more particularly for computer science education.

Across the undergraduate curriculum, instructor (and teaching assistant) assignments for introductory courses are not based on teaching excellence and commitment. More typically first courses in a discipline are taught in a manner that fails to stimulate student interest or involve students in extending their learning within the discipline. Too often introductory courses fail to capitalize on students' strong motivation to affirm their major, rather, introductory courses often provide the basis for students' determinations as to fields they *do not* wish to pursue.

The implications are clear. Computer science departments must change their orientation to be customer-focused in order to improve student retention. Freshman year courses must reflect a commitment to support students' graduation rather than an attempt to weed out those students who are "not capable of doing computer science." Computer science departments must support students with the best text and reference materials available. Students deserve to have the opportunity to be involved in their field from the outset. An applications course, such as CS 101, fails to prepare students for future work in computer science or answer any of their questions about opportunities in their chosen field. Standards for high school preparation in computer science are not well established. Expectations for prior programming experience in freshman year computer science courses, however, are the norm. Expectations for prior experience restrict the field to those privileged to have the opportunity for

experience with computing. Until standard high school preparation in computer science is available to all students, colleges and universities must be prepared to provide students with the background and support necessary for success in introductory computer science courses.

In CS 111 and the discrete mathematics courses, students faced great difficulties in their attempts to master difficult content and keep pace with instruction. Students who persisted, perceived course difficulties arising from difficult course content. Students who viewed their difficulties with CS 111 and discrete mathematics as a reflection on their own abilities, felt pushed to other majors. The experience of difficult, time consuming courses in the sciences is typical (Tobias, 1990). However, students who enjoy their freshman year courses in their major are more likely to persist (Ware, Steckler, & Leserman, 1985). The established pattern is that difficult freshman year courses in the sciences push many capable and talented students to leave the sciences.

The discrete mathematics requirement in the students' first college term was a factor specific to the university setting of this research. MA 201 was acknowledged within the mathematics department as a difficult course. As first term freshmen, few students had adequate study skills and mathematical maturity to meet the demands of the course. First term enrollment in the course coincided with the students' enrollment in a computer applications course, CS 101, rather than a computer science course more indicative of their chosen major. With discrete mathematics instructors who did a poor job of linking course content to computer science, freshman computer science majors lacked the computer science background to make the links for themselves. Using what little information they had about their major, the students struggled to affirm computer science as the right choice for their major. In their first term, the students in this study received messages of discouragement about their major from MA 201 and were frustrated to learn little about computer science in CS 101.

The results of this research clearly indicate that students would be better served by enrollment in discrete mathematics at a point in their undergraduate work after they have developed some background in computer science. With later enrollment, students have a chance to develop study skills and a readiness for mathematical proof essential for success in a difficult course such as discrete mathematics. At that point, students will have extended their background and experience in computer science and

mathematics thereby enabling them to master the course content with understanding for the mathematics and computer science context of their learning. Additionally, computer science department faculty expertise should be utilized to help discrete mathematics teaching faculty use examples and contexts that situate course content in a manner that would better meet the needs of computer science students.

The intensive data of this research portray the reality of students' differences in needs and preferred support structures. While Heather was intimidated by the ACM meeting, the same gathering of students welcomed Eddie and gave him a sense of connection to computer science. The students found support in their contacts with the researcher but Heather and Eddie made extensive use of e-mail while Samantha and Trent preferred the interaction of face-to-face conversation. Heather made every effort to complete her work from her room. Samantha wanted to be with other people and appreciated the computer laboratory setting. In supporting the graduation of second tier students, interventions and support systems must be designed with recognition that a range of opportunities must be provided to meet a range of student needs and personalities.

The support that students found in the WISE (Women in Science and Engineering) program and via their researcher contacts, underscores the importance of various forms of student support. Students in their freshman year face difficult social and academic transitions. This research makes clear that students need to find a range of support options. From peer mentoring to WISE programs and other student organizations, to mentoring by professionals in computer science, one solution will not meet the needs of all tiers of students currently turned away from computer science. Creativity and sensitivity is needed in the design of interventions and support systems for undergraduates in computer science.

Although gender discrimination factors were not mentioned by the student research participants, such factors were a part of the observation data of this research. The literature provided a wealth of evidence that subtle gender discrimination factors operate to produce a "chilly climate" for women in male-dominated fields. In spite of the volume of attention given to issues of gender discrimination, this research portrayed much room for change. Teaching must continue to be informed by consciousness raising efforts and training in alternative styles of classroom interaction

and language. Programs such as the WISE program must continue to be available to educate and support female students in male-dominated fields.

Consistent for all the students in this research, was the fact that they found little value in their advising experiences. The literature recognizes advising as one of the weakest links in undergraduate education while recommending that a strong advising system is particularly important for first-year students (Erickson & Strommer, 1991). The results of this research show that peer advising might be more comfortable for some students. Effective advising cannot be expected from already overloaded faculty members with no training for advising. Additionally, advising cannot be effective if advisors do not understand the student experience or have some personal knowledge of their advisees. It is essential that advisors are able to listen effectively and understand student development. Persons lacking essential advising skills should not be expected to advise well. Training should be available for those persons expected to advise undergraduates and recognition should be given for faculty time required to advise well.

Freshmen come to the first courses in their major with little understanding of work and opportunities available in the field. While their choice of major is premature for most students, their enrollment in introductory computer science courses expresses an interest in the field. Entry into college is marked by students' focus on career choice and preparation. Career counseling in high school is perceived within a different frame of reference than the reality of college coursework. As expressed by the students in this study, Tobias (1990) also observed that, "[College] students want more information about job availability, career options, and career alternatives. . . . They want to know what is required for different specialties, how to get experience so that they can anticipate what will be the payoffs and pressures of different specializations" (p 80). First year courses in computer science need to convey a sense of the field, its range of work and opportunities, to students.

Students struggled to complete CS 111 programming assignments and in their struggles, focused on issues of syntax. Their difficulties with syntax virtually excluded development of an understanding of the underlying programming principles. Completion of assignments misled students into thinking that they understood the course material. Rick was stymied by students' difficulties in moving from examples to original code. Clearly, teaching programming logic is much more difficult than

teaching programming language syntax. Difficulty notwithstanding, an understanding of programming principles, rather than language syntax, needs to be developed in introductory courses. Graduate teaching assistants with minimal teaching skills or commitment to teaching should serve in support roles rather than teaching roles in introductory courses. Instruction must be supported by good texts and reference materials. Students need to have experience (and adequate time) with many examples. Additionally, students need the chance to read and write many lines of code.

As Rick observed, teaching faculty could be helped by peer review of their teaching. This research showed that a classroom observer experienced in the teaching content can inform and support improved teaching. The classroom observer can contribute personal perceptions of the experience as well as be available to gather perceptions from students in the course. As undergraduate computer science instructors work to improve teaching in a field unique for its lack of pre-college preparation, teaching faculty must work with their peers to raise the standard of instruction.

While inadequate study skills are not a problem unique to computer science education, the results of this research indicated the student's need to develop study skills appropriate for the demands of college coursework. As the literature suggests, "It appears less and less that learning how to learn is a prerequisite that students should have mastered before admission to college. . . . Students' views of knowledge and learning undergo transformations during the college years. With those transformations come changes in students' readiness and willingness to engage in different strategies for studying" (Erickson & Strommer, 1991, p. 77). The students in this research exemplified the differences that students bring to freshman year courses. Instructors of freshman year courses need to be aware of student differences in study habits, learning styles, prior experiences, interests, abilities, and goals for college. Successful students will develop new strategies for learning in college. Colleges and universities need to provide students with support and training that equips students with study skills appropriate for their evolving modes of learning.

Finally, this research has clear implications for research data gathering. The results of this research clearly highlighted the potential for e-mail to serve as a comfortable and available means of contact with research participants. When accessible to both researcher and participants, e-mail allows the research to

accomodate participants' individual preferences for conversation style. Additionally, use of e-mail simulates contact with the researcher that is readily available, available when participants feel most like talking.

Recommendations for Future Research

The current study is significant in the depth of description it provides of the student and instructor experience in undergraduate computer science education. Such a thorough understanding of the experience is lacking in the literature. Although the current study indicates important changes in computer science education, this research was limited to five students in one university setting. Potentially excellent computer scientists are lost at all points in the education pipeline. Similar research, utilizing in-depth data gathering, is needed at points throughout the pipeline, elementary school, middle school, high school, undergraduate, and graduate school.

As students enter college with a tentative idea of their major, this research emphasizes the need to provide students with information about careers and opportunities within their chosen field of study. Whether printed or video material, lectures or mentorships by professionals in the field, work experiences and internships in industry, or a plethora of other forms, further research is indicated to determine what form of career input is most meaningful and useful to students.

The results of this research indicate the importance of caring support for freshmen undergraduates. Students found support in the researcher (via e-mail and in person), the WISE program, their peers, and their families. The importance, particularly for women, of the support of friends and significant others has been a frequent finding in the literature (Carter & Kirkup, 1990; Harrington, 1990/1991; Jagacinski, LeBold, & Salvendy, 1988; Kersteen, Linn, Clancy, & Hardyck, 1988; McIlwee & Robinson, 1992). On the other hand, McIlwee and Robinson caution that, "Having someone to encourage you, 'show you the ropes,' and ease your way through a difficult curriculum may smooth that process. But it may do so at the expense of self-confidence" (p. 65).

The current research clarifies that the forms of support required vary with each student. Heather and Samantha counted on support from their fathers. Devon prized his "80 instant friends" in the fraternity. Heather and Samantha appreciated having

friends next door, in the WISE dorm wing, who could help with course work. Trent enjoyed his conversations with the researcher. Eddie found that writing e-mail to the researcher was similar to talking to his high school psychologist. Peer, adult, and professional mentors, buddy systems, group support, individual support in person and via e-mail, the literature highlights model schemes (Carter & Kirkup, 1990), offers suggestions from researchers (Lipson & Tobias, 1991), and reports of intervention attempts (Hrabowski & Maton, 1995; Miller & Silver, 1992; Thile & Matt, 1995). The research also warns of the difficulty in designing successful interventions. "Providing resources and support services does not necessarily mean that students will take advantage of them. The most academically advantaged seem to flourish with these support services, while the students who needed the most help did not seek it out" (Miller & Silver, 1992, p. 27). Although a significant body of research exists describing results of a multitude of intervention and mentorship programs, the current study points to a need for further research to design and evaluate the effectiveness of programs that offer flexible alternatives of support for students.

Students in the current research faced clear difficulties in their first course involving computer science content, CS 111. Difficulties in CS 111 were most pronounced if the students had no prior experience with computer programming. Computer science is a discipline unique in the respect that it officially demands no academic computer science preparation prior to first courses in the undergraduate curriculum. While supporting mathematics prerequisites are clearly designated, prior computing experience is rarely specified for introductory computer science courses. As already noted, however, prior computing experience is a practical prerequisite for most introductory computer science courses and students without prior computing experience are effectively weeded out of computer science.

From Karel the Robot to Logo to Bernstein's (1992) new introduction to computer science, computer science educators have long struggled with how best to teach introductory concepts in computer science and computer programming. The results of this research underscore the need for further research and design of appropriate introductory experiences in computer science and computer programming, whether offered prior to college or at the undergraduate level. Only when appropriate introductory experiences are made available will the field of computer science truly be accessible to *all* students.

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APPENDICES

APPENDIX A

Student Informed Consent Form

This study is a part of research attempting to describe the experience of first year undergraduate computer science students. The research will provide answers to such questions as, What factors are encouraging students to pursue computer science as a major? What barriers do students encounter as they complete the introductory course sequence in computer science? By capturing a complete picture of the freshman student experience, this research will provide valuable information needed to direct changes in the structure and content of computer science education which will support a broader range of students in successfully completing a computer science major.

Participation will be for the Fall and Winter term of the 1993-94 school year. Three audio-taped interviews will be conducted, one before Fall term, one during the first week of Winter term, and one after Winter term. The researcher will be observing classes and will be available for informal conversation throughout the period of the study. Participants will also make journal entries once a week (submitted via electronic mail) describing personal experiences as they complete their computer science course work. Participants will benefit from early training and access to electronic mail resources. Discussions with the researcher (in person and via electronic mail) will be an opportunity for participants to engage in discussion with someone who is interested in their success.

The researcher will be the only person with access to all data collected (interview tapes, electronic mail files, and observation fieldnotes). Interview tapes will be stored in a locked cabinet in the researcher's office. Electronic mail will be accessed twice daily with files transferred to a password protected diskette stored at the researcher's home. Observation fieldnotes will also be stored on a password protected diskette. Pseudonyms will be used for the university and all subjects when reporting any of the results of this research.

Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled. The subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

Questions about the research, personal rights, or research-related injuries should be directed to: Dr. Margaret L. Niess at 737-1818.

Name: _____ Date: _____

APPENDIX B

Faculty Informed Consent Form

This study is a part of research attempting to describe the experience of first year undergraduate computer science students. The research will provide answers to such questions as, What factors are encouraging students to pursue computer science as a major? What barriers do students encounter as they complete the introductory course sequence in computer science? By capturing a complete picture of the freshman student experience, this research will provide valuable information needed to direct changes in the structure and content of computer science education which will support a broader range of students in successfully completing a computer science major.

Participation will be for the Fall and/or Winter term of the 1993-94 school year, during the period of time CS 101 and CS 111 are in progress. Audio-taped interviews will be conducted before each course begins and after each course is completed. The researcher will be observing classes and will be available for informal conversation throughout the period of the study. Participants will also make journal entries once a week (submitted via electronic mail) describing personal experiences and decisions as the course progresses. This faculty perspective will be invaluable in capturing a complete picture of the students' experience. Discussions with the researcher (in person and via electronic mail) will be an opportunity for participants to engage in discussion with someone who is also interested in improving the experience of undergraduate computer science students.

The researcher will be the only person with access to all data collected (interview tapes, electronic mail files, and observation fieldnotes). Interview tapes will be stored in a locked cabinet in the researcher's office. Electronic mail will be accessed twice daily with files transferred to a password protected diskette stored at the researcher's home. Observation fieldnotes will also be stored on a password protected diskette. Pseudonyms will be used for the university and all subjects when reporting any of the results of this research.

Participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which the subject is otherwise entitled. The subject may discontinue participation at any time without penalty or loss of benefits to which the subject is otherwise entitled.

Questions about the research, personal rights, or research-related injuries should be directed to: Dr. Margaret L. Niess at 737-1818.

Name: _____ Date: _____

APPENDIX C

Letter to Solicit Volunteer Student Participants

The computer science department has identified you as a freshman computer science major for the Fall term. You have chosen a field of study that continues to change rapidly and is unique in the format and demands of coursework. Some persons feel more comfortable than others in doing what is required to finish your degree. The computer science department would like to do whatever is possible to support **all** of you in attaining your computer science degree.

I am a doctoral student in the Department of Science and Math Education. In order to learn what the university is doing well and where there is room for improvement, the research I will be conducting will attempt to document your experiences as you complete the first two courses in the freshman computer science sequence.

I need only a few participants and will choose randomly from those willing to participate. If you do participate, your involvement with the study would be for the Fall and Winter term of the 1993-94 school year. Three audio-taped interviews (approximately 30 minutes in length) will be conducted, one before Fall term, one during the first week of Winter term, and one after Winter term. I will be observing classes and will be available for informal conversation throughout the period of the study. Participants will also make journal entries once a week (submitted via electronic mail) describing personal experiences as they complete their computer science course work. Comments to me will be kept strictly confidential and participants will, of course, remain anonymous as this research is reported. Pseudonyms will be used for the university and all subjects when reporting any of the results of this research.

Those persons participating will benefit from early training and access to electronic mail resources. Discussions with the researcher (in person and via electronic mail) will be an opportunity for participants to engage in discussion with someone who is interested in their success.

Your participation is voluntary, refusal to participate will involve no penalty or loss of benefits. Please contact me with any questions, I can be reached at: [Researcher's address and telephone number listed]

If you are interested in participating, return the enclosed card and I will contact you again within the next two weeks regarding your participation.

Thank you for considering involvement with this important project.

APPENDIX D

Student Participants' Post-Study Experiences

Heather's Post-Study Experience

In April of 1996, Heather's junior year, I sent Heather an e-mail note asking her to write her section answering the question, "Where are they now?"

> Where am i now?? Well I'm pretty happy where I'm at now. After a very troublesome year last year, [my sophomore year], I've enjoyed my new major, geography, [this year]. What made me change my major? Mostly frustration, I was frustrated with trying to do well in the required classes and then failing them. I got tired of doing this so I felt that it would be better if I changed majors [to a field] where I could do better and be less frustrated. [Geography] is kind of fun. [I] learn lots of neat stuff especially on how to create maps. I'm minoring in CS [computer science] though, so at least my first year and a half won't go to waste. I still want to keep some computer aspect in my career; [I] just don't know what at the moment. [My] graduation date is unknown. A friend and I decided that we must have some kind of degree by the year 2000 or else. I work for [the University] Information Services in the computer labs as a consultant. It has its moments, but for the most part I like the job.

Samantha's Post-Study Experience

I spoke to Samantha the weekend before finals week, Spring term of her freshman year. I learned that Samantha had changed her major to civil engineering, her roommate's major.

> I decided that CS just wasn't my thing and especially this term I've had a hard time trying to understand what was being taught. I think I just can't think the way I'm supposed to in order to grasp the material. This term was really bad for CS. I've done bad on both the midterms and I'm really scared about the final. . . . I guess the feeling I got from this [Spring term] course was that the CS department was really trying to weed out all the people who didn't have a lot of experience, like me, and I know this is needed, but I also thought college was a place to learn more than compete. I just was really discouraged by this

> course and I think the CS department should offer CS 101 if people need it, but not require it, and make more time for the material presented in CS 102 and 103 so it can be better understood.
>
> About me, I'm kind of upset that I changed my major because I thought it was something I really wanted to do. I'm sure I'll be happy in CE [civil engineering] though. I have a lot of catching up to do, however.

In March of 1996, Samantha's junior year, I happened to meet Samantha on campus. Samantha was happy and was still a civil engineering major. She enjoyed her major and was doing well academically. She was also president of her sorority. Additionally, Samantha was excited to tell me that she had just been awarded a full scholarship to support her final two years of undergraduate work.

Trent's Post-Study Experience

Late in his sophomore year, Trent contacted me to write a recommendation for his application to study abroad in his junior year. Trent felt that I was one of a few people on campus who knew him well. When I attempted to contact Trent in April of 1996, I found that Trent was studying in England.

From my conversation with Trent's mother in April of 1996, I learned that Trent was a philosophy major with a business minor who planned to complete a Master's degree (probably in business) when he finished his undergraduate work. Recent reflections, however, led him to think that a person with a philosophy major probably had few career options. Trent's reflections returned his thoughts to computing. Trent planned to take more computing courses to support his interests in business. He was not interested at all in programming but knew that a strong background in computing was an asset in business.

Near the end of April, 1996, Trent responded to my e-mail note sent to him in England.

> [England] has been very good to me. I'm not sure if I ever properly thanked you for the letter of recommendation that you wrote for me, but if it wasn't for people like you helping me along the way with things like that, I would not be here with all the personal and intellectual opportunities to grow that I have.

> I have taken mostly Philosophy classes while I have been here, but after traveling through Austria by myself for a few weeks during winter, I got the computer bug again. During the winter term here I sat in on all the lectures of an engineering introduction to computer operating systems class. It confirmed my suspicions that I would like to be involved with computers for a living. So, I have decided that when I get back to [the University], in addition to finishing up my degree in Philosophy, I will also work on an MIS [Management Information Systems] option through the college of business. It will tag at least one additional year onto my stay at [the University], but I am in no hurry to go out into the 'real' world (not to mention the fact that I might be able to get a job when it is all said and done).

Devon's Post-Study Experience

I sent Devon an e-mail note in April of 1996, asking him to write his answer to the question, "Where are they now?" Devon did not respond for a few days but, using *finger,* I knew that Devon was, now in his junior year, using e-mail on a regular basis. When I did hear from Devon, his response was only to tell me that he did not have time to write an update for me until a busy week was finished for him.

> This week . . . is a busy one for me. The fraternity house has initiation junk and stuff of that nature all week until Saturday morning. Then I will spend the weekend catching up on the school work that has been put on hold for this week. So I will e-mail you . . . after [Saturday]. . . . For some reason I can't think really well right now. (No, not because of alcohol.) So much stuff is clogging my brain. I guess I need to keep it simple for now. Expect the mail on Monday.

Clearly, fraternity social activities were still a priority with Devon. When I did not receive mail from Devon on Monday (or Tuesday or Wednesday), I checked the University academic records to determine the direction of Devon's academic pursuits. After withdrawing from two courses, and earning a 1.9 GPA (grade point average) in his first two terms in college, Devon completed four baccalaureate core courses in the third term of his freshman year and earned a 2.9 GPA for the term. In his sophomore year, Devon began to pursue a business major. Devon withdrew from two courses in his sophomore year but earned a 2.6 GPA for the year. Devon continued to pursue a

business major in his junior year, completing all courses for which he enrolled and earning a 3.1 GPA in his first two terms.

Eddie's Post-Study Experience

To begin his sophomore year, Eddie transferred to a university with an architecture program. Eddie was too late in making his decision to transfer and could not be admitted to the architecture program. Therefore, Eddie continued to pursue a business major.

In February of his second year in college, Eddie wrote me a note to update me on his life.

> Briefly, it occurs to me more and more how out of place and unsatisfied I was last year. This year is tremendously better, although it isn't heaven yet. Anyway, I think one important change is that I remember writing last year that my reason for being in college was to learn some skills so that I could get a good job and support a happy family. The job didn't really matter as long as it was upper middle class (kind of like my dad's job). My family was going to be what I derived satisfaction from.
>
> That's all changed. I went and heard [a] motivational speaker . . . for a leadership seminar last month. (I'm in dorm government.) I had heard him before at [the University], and knew how good he was. He said a lot of stuff that has gotten me to change some things in my life, as I see it, for the better.
>
> He pointed out just how long it is that people work for, around 40 years, and I decided that if I'm going to do something for 40 years, I better enjoy it. I'm not going to sacrifice that much of my life, and I don't have to. Also, I was all set on graduating in 4 years and getting on with my life. Well, Feb. '95 is a lot closer to that than Oct. '93 was, and while I could still easily graduate in 4 years, I'm not sure that there's that hurry anymore. I don't think renting a house and working 50-60 hours a week for a job of $27,000 a year if I'm lucky is better than college, and if I only work 39 or 38 years instead of 40, would it really make that much of a difference?
>
> I've decided to (and it takes a fair amount of effort) make these days the "good old days" and enjoy right now; to find things I like doing and that I'm good at doing and finding a way to get paid for doing them. The cooks have a quote board outside the cafeteria, and they wrote, "If you have a job you love, you'll never have to work a day in your life." I know that's true.
>
> One last thing . . . , computers are coming back full circle, I hope. Since [the Spring fraternity] sing in the fraternity last year (yes, even

some good came out of it) I have become more involved with something I used to be really good at, music.

[My new university] has a really good music department, I got a pretty nice keyboard for Christmas with MIDI capabilities, and my dad got a pretty capable computer at home with digital sampling and a CD rom. All of this has prompted me to explore the path of Music Technology, the mixing, sampling, recording, composing, and editing aspect of music. I couldn't go into those classes full force until next year, but this spring I am taking a 400 level electronic music class to see if that really is something I want to pursue.

In April of 1996, Eddie's junior year, I asked Eddie, via e-mail, to write his section answering the question, "Where are they now?"

I am still living in the dorms at [my new university]. I am still on track to graduate in June of '97. My degree will be in Business Administration, and my concentration (that's how this school does it now) will be most likely in marketing but maybe entrepreneurship. I don't have a clear idea of what I want to do upon graduating, but ideas that surface the most often are working as a technical writer or in the real estate field. I've been told that one of my strengths is writing, (I agree) so I am taking as many writing courses as I can before I graduate. I intend for my writing ability to be my entrance to a job where I can learn about the field or industry and hopefully excel because of my creativity or responsibility.

As for school life, I have become somewhat more involved since abandoning the fraternity. I am vice president in my Professional Business Fraternity, membership chairman in my Junior Class Honor Society, and have been accepted to be an RA [resident assistant in the dorm] next year, which means free room and board as well as great work experience and dealing with people experience.

My involvement with computers is, well, limited. I still have the same old hopped up 386 IBM XT that I did my freshman year. I have taken some electronic music classes where I used Macs to compose pieces, and that has been about the most involved I have been. I still want to get a better computer of my own, and soon, so I can to digital 4-track recording. (When I transferred I became more heavily involved with music than I was before.)

I still kind of chuckle and think, "What was I thinking being a Computer Science major?" But I see now that I was pretty much entirely clueless for the entire years 1992-1994. I don't know why I think I have a clue now. Maybe it's because of a really good motivational speaker I saw in January of 1995 . . . who kind of got me focused, or maybe it's just from being on my own (no fraternity, no girlfriend [still]) for so long.

What is kind of ironic is that I was just thinking about how my purpose in college has changed since I wrote to you that it was "to get

the skills to get a good job to give my eventual family a comfortable lifestyle" or something like that. That was when graduation was about 44 months away. Now that it's in 14 months, I take kind of a different view of it.

Having a job I enjoy now is more important to me. Ask me again in 18 months and maybe just having a job will be important. Before, I intended to get joy and satisfaction from my family. I still do, the difference is that back then I sort of assumed I would have met someone by now and been in a position where I could think about family/marriage type things. Since that isn't the case, I am thinking about fun things to do that only single, unattached, zero responsibility people can do, namely just set out one day and travel. I am also coming off a spring break where I drove 2400 miles . . . so traveling is pretty heavily on my mind right now.

APPENDIX E

Evolution of the University's Computer Science Program

In the two years following the conclusion of this study, the computer science department lower division curriculum continued to develop and change. In April of 1996, the system of advising is now the responsibility of four faculty members who asked for the assignment rather than being required of all faculty members within the department.

A new course, CS 110: Computer Science Orientation, replaced CS 101 as the first required course for computer science majors. CS 110 is a non-graded (Satisfactory/Unsatisfactory only) orientation to the field of computer science. As an orientation course, CS 110 discusses topics such as careers in computer science, problem solving, working in teams, library skills, professionalism, professional ethics, and time management skills as well as a brief introduction to the major topics in computer science. Although the course introduces general concepts in computer science, it does not teach programming. Students in CS 110 work together in teams on the problem solving problems and other projects. The work in teams provides an opportunity for students to form relationships with other computer science majors. Several computer science faculty give brief lectures about their research interests. The faculty lectures give students a chance to meet some of the faculty. CS 110 students learn about careers in computer science through a presentation by an industry person and through contact via e-mail mentorships with department alumni working in industry.

Changes also occurred in requirements related to CS 111, the first computer science major's course with programming content. Programming experience in C is now a prerequisite for enrollment in CS 111. Changes in the scheduling of course offerings allow for students to enroll in an introductory programming course without falling behind in the sequence of required courses. Additionally, programming is recognized as a primary topic in CS 111 and the programming content is taught in lecture sessions rather than relegated to recitation teaching.

APPENDIX F

Researcher Reflections on the Study

With the volumes of data processed and the results in print, what words do I have about the process of conducting such a study? I still find the candor of the students somewhat amazing. Without their honesty, the study would have failed to capture such a true picture of the student experience of a first year undergraduate computer science major. The students' openness was based largely on the fact that they liked having someone listen to them. They liked to talk. One of my mistakes in the study was that I failed to arrange more frequent interviews with those students (all but Heather) who liked the interviews. The student data would have been even more voluminous.

My overriding concern in the conduct of the study was to capture the students' perspectives. As much as I might have wanted to ask particular questions at times, I let the students put the topics on the table for discussion. I was already asking them to be more reflective about their experiences than they normally would have been. I did not want to introduce my own personal factors of interest as grist in their mills for processing. In any case, more quantitative research with a larger sample is better suited to gathering information about researcher identified factors of interest. Clearly the strength of this study is its faithfulness to capturing and describing the operation of factors of importance to the students, not the researcher.

Additionally, I wanted to capture the experience of typical students who did not have the benefit of turning to a mentor for guidance and support. I did not want to serve as a mentor to the student participants. Although the students might have been confused about my role at times, they understood from the outset that I was a caring listener. They rarely asked me questions (beyond the technical, "e-mail how-to" sort). When they did ask me for information or guidance and I gave them little response, they were not frustrated. Rather, they assumed that, because of my researcher role, I was not free to tell all I knew. They kept talking. They liked being heard. They always understood that I would listen and care. The students had enough appreciation and respect for my role as a listener that they did not push me to also provide a mentor's guidance and support.